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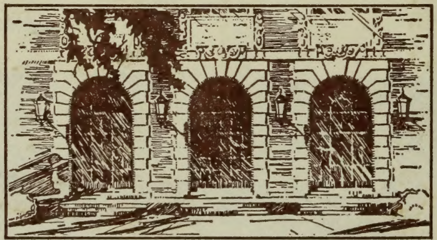

BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS

ASSOCIATION

(ENGLISH EDITION)

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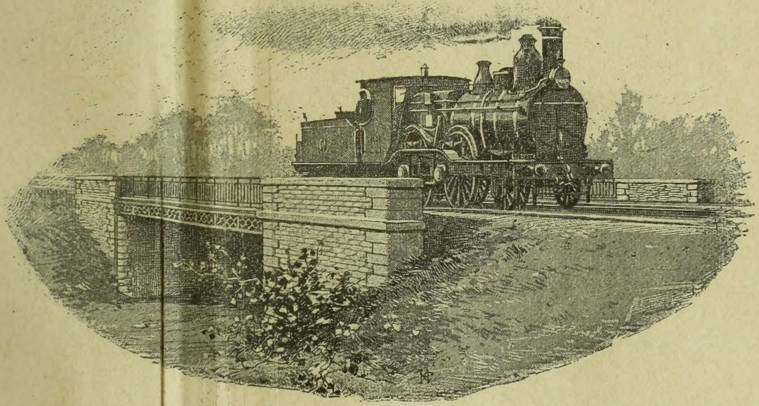

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BULLETIN

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NOTE

ON THE WORKING LOOSE OF SCREWS WHEN USED AS RAIL-FASTENINGS,

By L. SCHLÜSSEL,

ENGINEER, PARIS.

Figs. 1 to 9, pp. 6 to 22.

The readiness with which screws used as rail-fastenings work loose, and the resulting large cost of maintenance are well known facts.

On the other hand no subject has been investigated less, at least as far as the screws themselves are concerned.

The present paper is a contribution on this subject; it analyses one of the most obvious causes of this working loose, namely the behaviour of the screw under the influence of unsymmetrical loads; and then attempts to deduce, from these causes, a method for preventing such loosening.

I. — General considerations.

The screw is certainly the rail-fastening which is most generally used.

In the case of wooden sleepers, it is usually in the form of a screwspike; in that of the steel sleepers, in the form of a bolt and nut, the head of the bolt acting on the flange of the rail either direct, or through a clip-plate.

Now the screw, whatever its shape and the way in which it is used, works loose when the rolling loads keep on passing over the track.

Now as the most important constituent of the fastening is the screw, if the latter works loose there is no fastening; consequently continual supervision is required,

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and maintenance becomes more and more expensive as there is a tendency to increase the speed of the rolling loads.

It would seem that engineers have concentrated their attention on the " rail ", the weight of which goes on increasing, and on the " sleeper ", which has been made the subject of numerous investigations; but the " screw " which unites those two main members of the track is only mentioned with the remark that it tends to work loose. Now in our opinion the " screw " should be the starting point in investigating how to maintain rail-fastenings.

As long as the fastening is tight, the different parts forming the whole system react elastically on each other; but as soon as there is any slackness, however small in extent, the different parts enter into conflict and hammer each other. The stronger wears, cuts, crushes the weaker, and if a fastening which still looks of normal strength is taken to pieces after a while, an astonishing amount of damage may be observed in it, caused by the destructive action of very small forces, which, in many cases, are only the results of the repeated blows produced in a slack fastening.

There is no doubt that a well-designed fastening would last indefinitely, if no destructive cause upset its internal equilibrium; but it is just as certain that a screw-fastening subjected to repeated dynamic action becomes destroyed, and that in course of time, the screw obeys the variations in its fibre-strains, just as it has obeyed, at once, the spanner which was used to tighten it.

The working loose of the screws in the rail-fastenings is thus the primitive cause of their deformation; it is therefore the critical point, the defect which must be remedied before any other.

Mr. Cüenot, chief engineer of roads and bridges, recently published a new and very detailed investigation of the deformation of tracks, and on the methods for preventing these deformations. In it he states that in order to make higher speeds than the present possible, it will be necessary to use stiffer sleepers, to have sleepers under the joints, and to use stronger bedplates (¹).

These are very reasonable conclusions; but these measures will certainly lose much of their value if the fastenings used are such that the bolts and screwspikes will work loose when the new speeds are used.

Now such loosening is bound to take place, as it already occurs now. It is therefore necessary, in the first place, to try and prevent the working loose of the " screws ", for on them the tightness of the fastening depends.

Many different methods have been tried for preventing the working loose of screws, by supplying some external force capable of counteracting it; washers, pins, nuts, clip-plates, have been combined for the purposes. But the great number of methods used, while testifying to the importance of the question, show that the

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(¹) A summary of Mr. Cüenot's work will be found in the *Bulletin of the Railway Congress*, No. 8, August, 1906, p. 1344.

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problem is far from being solved; the appliances used, although imperfect, are complicated and consequently costly.

Before we try to discover methods for preventing screws from working loose, is it not logical to ascertain what are the causes for such working loose? Evidently; fo when we know the causes we may have a reasonable chance of success in counteracting the forces in question.

II. — Investigation into the causes of screws working loose.

The observation of a rail-fastening while a considerable rolling load is passing over it, is necessarily the starting point of this enquiry, as it is the rolling loads which deform the track.

The forces which act on the fastenings as a result of the wheel pressure on the rails, act in all directions, but they may be divided into three classes :

1° Vertical forces which bend the rail and the sleeper;
2° Transverse forces which tend to cant the rail and spread the track;
3° Longitudinal forces which tend to make the rail creep.

These three sets of forces have been made the subject of numerous investigations; but without neglecting the two latter, it has seemed to us that the vertical forces are of paramount importance in loosening the screws, and we have, therefore, tried to analyse these forces, in their action on the screw.

The following is a summary of the observations already made and taken by us as basis :

a) The rolling loads act vertically on the rails within limits which have been determined;

b) The maximum effect of a rolling load is about equal to twice the static load concerned;

c) The minimum effect of a rolling load is about equal to one fourth of the static load concerned;

d) The maximum static load a rail can bear has been ascertained experimentally with sufficient accuracy; it is a function of the weight of the rail;

e) The fastening, when a rolling load approaches, is in the first place subjected to vibration; when the load is still several metres from the fastening, the track bends, the rail secured by the fastening is depressed, bends the sleeper under the fastening and forces it into contact with the ballast; when the wheel passes over the fastening, the latter is pressed down on to the ballast, it follows the elastic movements of the latter, and then passes through the same movements in a reverse order, in order to resume its primitive position, quite or very nearly, as soon as the rolling load is sufficiently far off not to act any more on the rail in question.

From these observations we deduce :

1° That the fastening connecting rail and sleeper is subjected to a maximum vertical load of $2P$ and a minimum one of $\frac{P}{4}$, where P is the maximum static wheel-load the track can carry in practice;

2° That the fastening when in a state of rest is hung from the flange of the rail, or else supported by the sleeper which only touches the ballast at its ends;

3° That during the passage of the rolling load, the fastening is compressed between the ballast and the load, and subjected to a pressure varying between $2P$ and $\frac{P}{4}$, or, if we put Pm for the maximum load $2P$, between Pm and $\frac{Pm}{8}$.

Let there be a screw fastening; we will take a simple one consisting entirely of metal, namely the flange of a Vignoles rail secured to a metal sleeper by a metal screw, the head of which presses down the flange and the thread of which is screwed into a piece under the sleeper, the piece acting as a fixed nut (*see* figure 1).

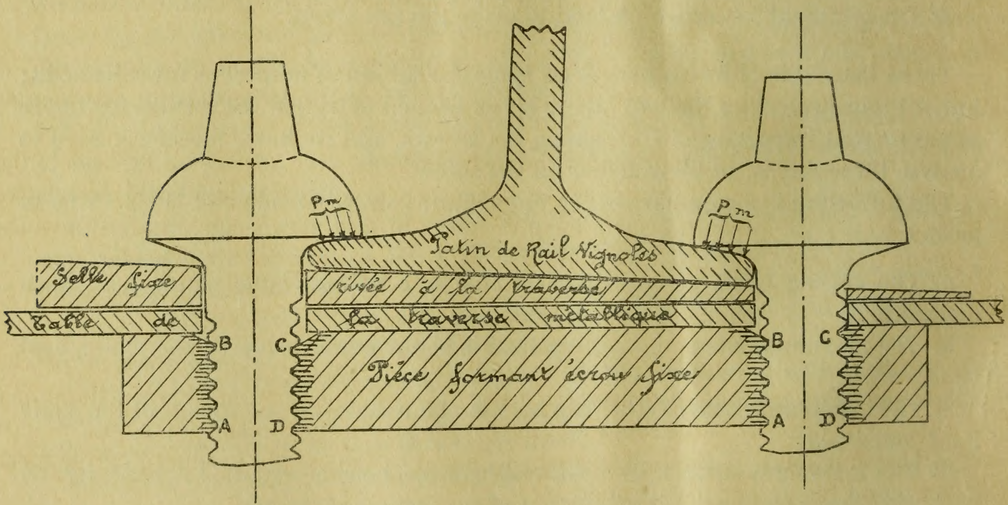


Fig. 1. — Typical fastening.

Explanation of French terms : Pièce formant écrou fixe = Piece forming fixed nut. — Patin de rail Vignoles = Flange of Vignoles rail. — Selle fixe rivée à la traverse = Bedplate riveted to sleeper. — Table de la traverse métallique = Top of metal sleeper.

This example seems to us sufficiently general, as the parts are in ordinary use and the forces produced are similar to those produced on any other tracks.

In spite of some differences in other more or less complicated systems, all the screws have only to resist *unsymmetrical forces*, applied to their heads either direct, or through clip-plates which in no way modify the *unsymmetrical nature of the forces.*

We will assume that this fastening has been well designed; by this we mean that the different parts are so proportioned that the maximum fibre-stress in no case exceeds the practical limit R the metal used can. stand; moreover we will assume, to simplify matters, that R is the same for all the different parts of the fastening.

That being so, the fastening must react elastically, *without any relative displacement* of its constituent parts (rail, sleeper, screw, nut), if it is not to suffer from the dynamic forces which come into play as soon as the fastening becomes loose.

This fastening must be tightened so that it can resist the external forces; it is therefore necessary that the variations of P, between Pm and $\frac{Pm}{8}$, find an equal resistance to prevent the relative displacement of the different parts; and that it may do so we must give the screw the dimensions necessary that any pressure up to Pm may meet with an equal resistance.

The tightening Pm is the result of the pressure of the head of the screw on the flange of the rail; this pressure reacts on that surface of the threads of the screw which is in contact with the threads of the nut (the latter being assumed fixed in our case; when the screw is assumed fixed, the nut is movable).

The pressure of the head of the screw on the flange is obtained by acting on the screw by means of a spanner; the turning movement applied makes the screw enter until Pm is obtained.

In this case we will not consider the wear on the bearing surface of the head of the screw or of the nut; for such wear cannot be produced unless there is relative displacement between the surfaces in contact; these are consequently only phenomena of a secondary order as compared with those which we are considering.

We know that a screw, when it is being tightened up, is subjected to two kinds of stresses which the fibres of the metal have to resist:

1° Horizontal torsional stresses, produced by the circular movement of the spanner; they are due to resistance to slip, *i. e.*, to the friction between the upper sides of the threads of the screw and the lower sides of the threads of the nut.

The sum total of these stresses is G, equal to the couple produced by the force acting on the end of the spanner.

If the screw is well designed, G must be distributed over a surface S sufficiently large for $\frac{G}{S}$ not to exceed Rg, or else the surfaces in contact are deformed permanently;

2° Vertical tensile stresses produced by the force overcoming the friction between the threads; these tensile stresses must amount to Pm in order that the fastening may be a good one.

If the screw is well designed, Pm must be distributed over a surface S sufficiently large for $\frac{Pm}{S}$ not to exceed R, or else the surfaces in contact are deformed permanently.

These two stresses are closely related, as the horizontal stresses produced by the spanner produce the vertical tensile stresses.

Now as these stresses act on one and the same surface S, there is between them a ratio which must be constant for one and the same value of S, whatever this surface may be.

Now as

$$\frac{Pm}{S} = R,$$

it follows that

$$S = \frac{Pm}{R}.$$

And as

$$\frac{G}{S} = Rg,$$

it follows that

$$S = \frac{G}{Rg}.$$

Therefore, no matter what the value of S,

$$\frac{Pm}{R} = \frac{G}{Rg} \quad \ldots\ldots\ldots\ldots \quad (1)$$

Now, in (1), as long as

$Pm > G$, then $R > Rg$, and the screw holds;

if

$Pm = G$, then $R = Rg$, and the screw is in unstable equilibrium;

if

$Pm < G$, then $R < Rg$, and the screw turns backwards,

for in the latter case, the sum of the horizontal stresses being greater than the sum of the vertical stresses, the elastic forces developed at the contact of the surfaces of sum S, act in a horizontal tangential direction on the threads of the screw and can produce unscrewing, particularly if the weight of the screw is counteracted by a tensile force lifting the threads.

What we are here considering is a very minute, but existing amount of unscrewing.

In other words : P and G form a resultant; when the resultant is vertical or nearly so, P*m* is > G and the screw holds; when the resultant is in an intermediate direction, R becomes more nearly equal to R*g* and the screw approaches a state of unstable equilibrium; but when the resultant of P*m* and G approaches the horizontal, the elastic forces developed at the contact of the surfaces tend to produce unscrewing, *the unit vertical elongation becoming less than the unit horizontal elongation.*

Now our argument is that under the influence of symmetrical tensile stresses modified by the influence of undesirable unsymmetrical stresses in the rail-fastenings, their screws, otherwise correctly designed, assume as soon as ever they are inserted the condition of unstable equilibrium, where R becomes nearly equal to R*g*; and then if P*m* is considerably reduced, as it may be by a heavy rolling load, P becomes < G and the screw becomes loosened.

Evidently other actions may make the phenomenon more complex and prevent the loosening, but such actions are only accidental in their nature and do not affect the value of this reasoning which practical experience entirely confirms.

The amount of loosening will be infinitely small if elastic forces only are concerned; but as soon as permanent deformations have increased, the play between the screw and the nut, the screw having more freedom will become unscrewed more readily, and as this action will be repeated each time a rolling load passes, the fastening will soon become useless if it is not tightened up.

To sum up : the screw, when first tightened, is, owing to the symmetrical and unsymmetrical tensile stresses, in a state approaching that of unstable equilibrium, and then any sudden reduction in P*m* results in P < G which produces unscrewing.

At the moment of unscrewing, the metal of the nut, strained by that of the screw under the action of the spanner, can be represented by figure 2, which shows, on an exaggerated scale, part of a section of a screw thread (lower side) taking against the corresponding part of the nut (upper side); it shows the useless part of what should be bearing surface, also shown in figure 4.

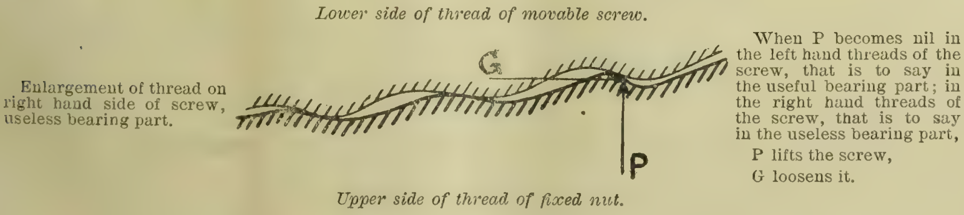

Lower side of thread of movable screw.
G
Enlargement of thread on right hand side of screw, useless bearing part.
When P becomes nil in the left hand threads of the screw, that is to say in the useful bearing part; in the right hand threads of the screw, that is to say in the useless bearing part,
P lifts the screw,
G loosens it.
P
Upper side of thread of fixed nut.

Fig. 2. — Vertical section, on an exaggerated scale, of a screw thread.

Let us now consider how this state is produced in screws.

III. — Analysis of the effects produced by the symmetrical and unsymmetrical forces acting on screws.

Let us once more consider figure 1, which represents a typical fastening.

In this fastening, the two screws which hold the flange should press it down with a force Pm; or each screw-head should produce $\frac{Pm}{2}$, if the two act equally.

But we cannot assume such equality, and we are compelled to assume that at a given moment either of the screws may by itself have to give the force Pm.

Now let us take this screw at the moment when all the available threads are in the nut, and P is being increased by the action of the spanner.

As soon as P has attained a certain value, the core of the screw tends to become deformed under the influence of the two following actions :

1° A linear elongation proportional to P, but as P varies from AD to BC in proportion to the reaction between the threads of the screw and the threads of the nut, this elongation is not the same at AD as at BC, and the difference, however small it may be, nevertheless does actually exist. The linear elongation due to symmetrical tensile forces will thus be greater at BC than at AD;

2° As P is unsymmetrical, this will tend to lengthen the fibres along AB and shorten the fibres along CD (right hand part of figure).

As these two actions are simultaneous, the sum will act along AB and the difference along CD; the result being that the body of the screw will become deformed as shown in figure 3, ABCD becoming A'B'C'D'.

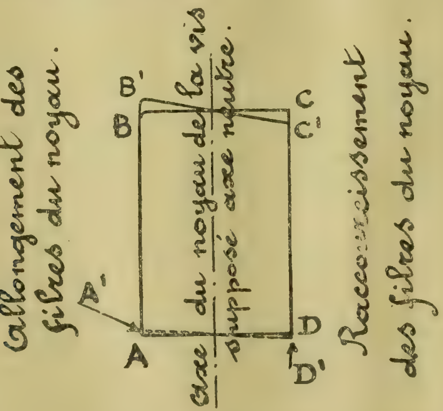

Allongement des fibres du noyau.
B'
B
C
C'
A'
A
D
D'
axe du noyau de la vis supposé axe neutre.
Raccourcissement des fibres du noyau.

Fig. 3. — Deformation of the core of the screw by the symmetrical, and more particularly by the unsymmetrical stresses.

Explanation of French terms : Allongement des fibres du noyau = Elongation of the fibres of the core. — Axe du noyau de la vis supposé axe neutre = Axis of core of screw, assumed to be neutral axis. — Raccourcissement des fibres du noyau = Contraction of the fibres of the core.

Now let us consider what will happen to the threads when the core of the screw is deformed in this way.

Let us take the threads nearest the head; they are shown on an enlarged scale in figure 4.

In this figure, fibre AB of the core has its upper surface marked 1, 2 and 3; fibre CD is similarly marked 4, 5 and 6.

The three upper screw threads, at the moment when P is too small to produce any deformation, are shown as unbroken lines.

Let us assume that P has become $\frac{Pm}{2}$, that is half the total pressure the screw has to produce; then the point 3 shifts to 3′; 2 to 2′; 1 to 1′. The elongation 1 — 1′ is smaller than 2 — 2′; the latter is smaller than 3 — 3′.

On the other side, on the contrary, 4 shifts to 4′; 5 to 5′; 6 to 6′. The difference 4 — 4′ is greater than 5 — 5′; the latter is greater than 6 — 6′.

During this movement of the body, the points 1, 2, 3, 4, 5 and 6 draw along the threads, which will become deformed, at first elastically, and this the more easily as they meet smaller resistances.

It is quite evident that the threads of the screw, near the bottom of the thread, will meet less resistance in bearing against the tops of the threads of the nut than the tops of the threads of the screw will in bearing against the bottom of the threads of the nut, as the last are stronger.

The elastic deformations of the different parts of the threads of the screw will thus be greater near the core than at the tops of the threads; they will therefore be maximums at 1, 2, 3, upwards, and 4, 5, 6, downwards.

As the amount of material in the thread cannot alter, the lower parts of the threads of the screw will follow the deformations of the upper parts.

The deformations of the threads are shown by the dotted lines and we may observe :

1° That the useful bearing surfaces such as 3′ — *b* will have the centre of their curvature above, while the idle surfaces such as *x* — *v* will have it below;

2° That the useless bearing surfaces such as *m* — *n* will have the centre of their curvature above, while the idle surfaces such as 4 — *c*′ will have it below.

These deformations are only elastic if the neutral exis of the body coincides with the axis of the screw, for the useful bearing surfaces of the screw bear on a surface which can be assumed equal to $\frac{S}{2}$ as a maximum; in all cases, if the two axes do not coincide, the neutral axis would be to the left and the useful bearing surface of the threads would then be less than $\frac{S}{2}$. Let us take this maximum, $\frac{S}{2}$; this gives

$$\frac{\frac{Pm}{2}}{\frac{S}{2}} = \frac{Pm}{S} = R.$$

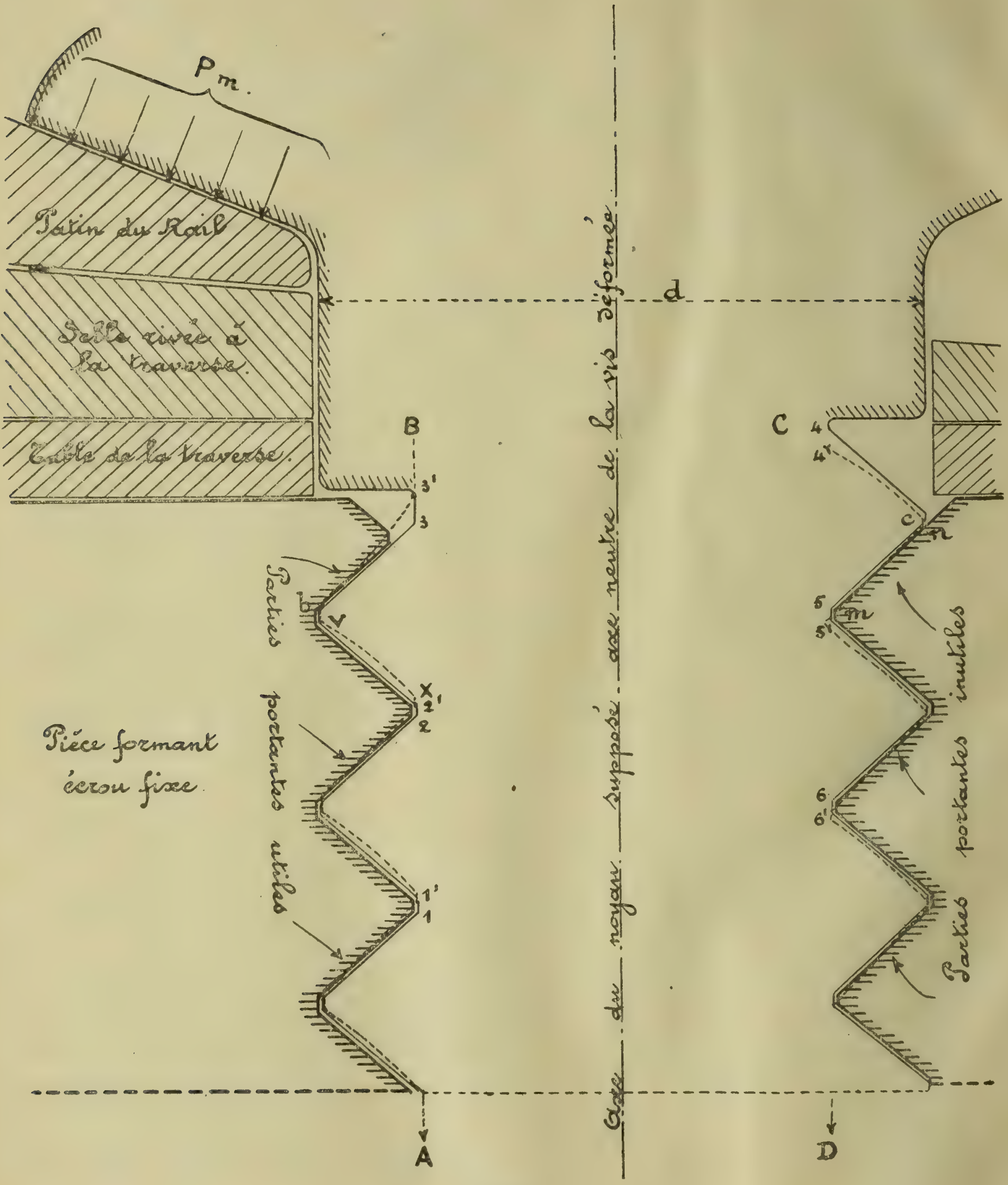

Pm.
Patin du Rail
Selle rivée à la traverse.
Table de la traverse.
Pièce formant écrou fixe.
Parties portantes utiles
Axe du noyau supposé axe neutre de la vis déformée
Parties portantes inutiles
d
B
C
A
D
3'
3
4
4'
5
5'
6
6'
2'
2
1'
1
X
V
b
c
n
m

Fig. 4.

Explanation of French terms : Patin du rail = Flange of rail. — Selle rivée à la traverse = Bedplate riveted to sleeper. — Table de la traverse = Top of sleeper. — Pièce formant écrou fixe = Piece forming fixed nut. — Parties portantes utiles = Useful bearing part. — Parties portantes inutiles = Useless bearing part. — Axe du noyau supposé axe neutre de la vis déformée = Axis of core. Assumed neutral axis of deformed screw.

For half the required force of the screw, the load per unit of surface is R, the accepted limit, and this value of R is just then a minimum, because :

1° The actual bearing surfaces may be less than $\frac{S}{2}$;

2° We have not taken into consideration the reactions of the useless bearing surface;

3° We have neglected the effects of torsion.

But let us drive in the screw until the pressure P*m* for which the screw has been designed has been attained; the elastic actions described above will go on increasing and R will per unit of useful bearing surface become

$$\frac{Pm}{\frac{S}{2}} = 2R$$

which can already produce permanent deformation, for 2R is a minimum, owing to the possibilities mentioned above.

What have the stresses G become? Similarly to P and by the action of the spanner producing them, the sum total of the forces overcoming the friction has become increased, in the first place, squeezing out the grease and reducing the rubbing surfaces to the state of unlubricated metal to metal; then as P increases, G also increases by the friction of the useless bearing surfaces and the *molecules of the nut, forced along by those of the screw*, form at the points of contact a true spring so that the screw, if released from its tensile stresses, would be turned back by the horizontal and tangential action of the molecules of the fixed nut, which have been displaced elastically under the action of

$$\frac{G}{\frac{S}{2}} = 2Rg.$$

The screw is at this moment in a *latent state of unscrewing*, which may be defined mathematically by :

$Pm = \int P_1 - \int P_2$, where P_2 tends to raise the screw;

$Gm = \int G_1 + \int G_2$, where G_1 and G_2 tend to turn it backwards.

Thus the mere fact that this new screw is used for unsymmetrical stresses of P*m* makes it impossible for it to act as designed.

We assumed that the tensile stresses P*m* were distributed over a total surface S; now the surface is actually less than $\frac{S}{2}$.

We assumed that the stress per unit of surface must not exceed R, the practical working limit; now it exceeds 2R.

We assumed that the stresses due to the friction of the sliding surfaces must not exceed Rg; now they exceed 2Rg.

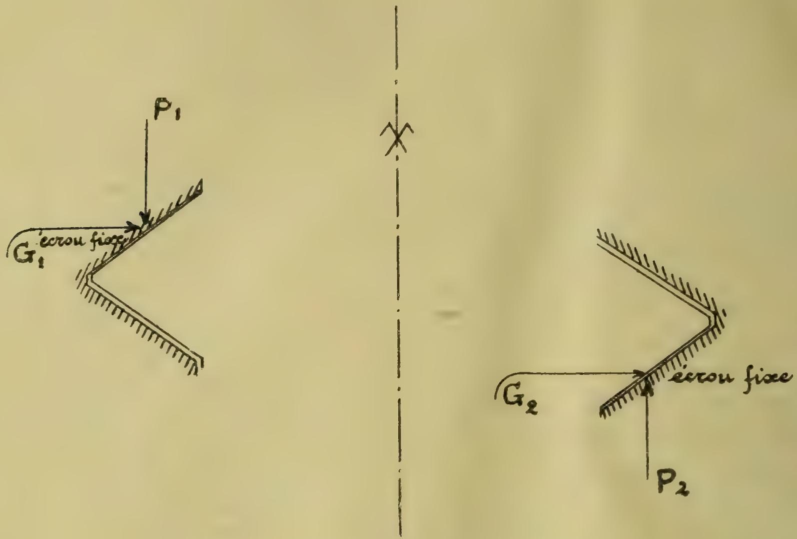


Fig. 5.

Explanation of French terms : Écrou fixe = Fixed nut.

Finally, it was assumed that only the upper surfaces of the threads of the screw would distribute the force Pm; now this is not the case. The lower surfaces of the threads are also in contact, increasing the resistance to the spanner, and *producing tensile stresses opposed* to those which it is desired to produce.

In short, the useful bearing surfaces are reduced, and useless bearing surfaces are produced; the latter tend, on the one hand, to raise the screw, whereas the reactions of G, then set free, tend to turn it backwards. In other words, these useless bearing surfaces act as a sort of internal spanner always ready to reproduce, *in an inverse direction*, the two movements of the screw when entering.

This *latent state of unscrewing* produced by the unsymmetrical forces on the screw is the state of *unstable equilibrium* described above, when R is nearly equal to Rg; and what upsets the equilibrium is just the sudden reduction of Pm by the action of a rolling load, with the result that $P < G$.

Let us now consider how the screw in the fastening in question becomes unscrewed.

We know that the screw, when in the latent state of unscrewing described above, holds the sleeper hung from the flange of the rail.

When the rolling load approaches, the rail bends and the sleeper follows this movement; the fastening moves down towards the ballast, and when the rolling load passes, the different parts of the fastening, other than the screw, are pressed together by a pressure varying from $\frac{Pm}{8}$ to P*m*.

The screw which has been designed for a pressure P*m*, which value is already double that of equal distribution, will no longer hold anything when the pressure is P*m*; *the tensile stresses will be reduced until they become nil.*

During the time, more or less long, which a train takes in passing, we then will observe that:

1° The threads of the screw, side 1, 2, 3 will go down;
2° The threads of the screw, side 4, 5, 6 will go up.

This will result in a slight raising of the screw which, freed from its tensile stresses, will then have $P < G$; the reactions of G then produce unscrewing.

These movements will take place through the normal and abnormal play of the screw as soon as P*m* is reduced; and when the rolling load no longer acts, the fastening will once more resume its position; but the constituent part which really holds the fastening together, the screw, will have been displaced relatively to the other parts. The initial pressure of the screw will no longer be P*m*, but $Pn < Pm$; and this relative displacement of the screw will be continued whenever any rolling load reduces P materially.

The fastening thus becomes loosened gradually; blows will be produced as soon as the fastening is sufficiently loose, and it will then be quickly destroyed.

If the screw is tightened up again, the process is repeated but the fastening is not as firm as originally, as the dynamic forces have permanently injured the threads, the useful bearing surfaces becoming progressively reduced thereby. Consequently, the greater amount of play leaves the screw more free to become loose.

We think we have explained the quick destruction of screw rail-fastenings.

We would recall that the causes of the loosening of screw rail-fastenings are, in order of their importance:

1° The *symmetrical* and *unsymmetrical* tensile stresses to which the screws acting as fastenings are subjected;

2° The *variations* produced in these stresses by the rolling loads.

The unsymmetrical stresses give the “ screw ” a position approaching that of unstable equilibrium; they vary during the passage of the rolling loads, and this variation produces loosenings.

The symmetrical stresses elongate the “ screw ” irregularly and the unequal distribution of the pressure on the threads can by itself give rise to permanent deformation, as Mr. Bodin proves in his course at the *Ecole centrale des arts et manufactures.*

Now that we know the causes, it is from them that we must deduce *what to do to improve matters.*

It would be very advisable to eliminate the *unsymmetrical stresses*, if this were possible; but these stresses and their variations are the result of the movements of the rolling loads. Now as we must have rolling loads, we are bound to accept the consequences.

It is therefore necessary for the " track " to resist all the stresses which the rolling loads produce, and hence we have to see what improvements can be made in the screw itself in order to prevent loosening.

Now the preceding considerations show that the chief defect of the " screw " is the bad distribution of the tensile stresses.

It is, therefore, logical to consider how better to distribute the pressure on the threads.

Looking at it from this point of view, the analysis of the tightening of the screw has shown :

1° That the pressure only affects half the thread, on its upper surface and at the side of the rail;

2° That this pressure is unequally distributed over the upper surfaces of these half-threads.

It follows that it is necessary, in order to obtain a better distribution :

a) To double the upper bearing surface;

b) To reduce to unity the number of half-threads.

a) To increase the upper bearing surface of the half-threads, while at the same time retaining a core of sufficiently large cross-section, can be done in three ways :

1° The cross-section of core sufficient for P*m* is retained, and the surface of the half-threads is doubled, that is to say of the whole threads, so as to retain the form of a screw; this solution, in doubling the depth of the thread, takes away all the strength of the thread if the pitch of the thread remains the same; and if the pitch of thread is doubled at the same time, the threaded part of the screw becomes twice as long.

The increase in the bearing surface will then be too expensive; this will only be a half-improvement which we cannot accept;

2° The cross-section of the core is retained and the number of threads is doubled; this solution must be rejected as it increases the number of the threads, whereas we ought on the contrary try to reduce it;

3° The same number of threads is retained and the cross-section of the core is modified so that its diameter remains $d = 0{\cdot}84$ D, as in ordinary practice, while the useful surface of the threads is doubled.

This latter solution, which we only accept as a guide, as the number of threads is not reduced, would give a screw having a total diameter Δ and a diameter of core δ as given by the equation :

$$n\frac{\pi}{4}(\Delta^2-\delta^2)=n\frac{2\pi}{4}(D^2-d^2),$$

where

$$d=0{\cdot}84D \text{ and } \delta=0{\cdot}84\Delta;$$

therefore

$$\Delta=D\sqrt{2} \text{ and } \delta=1{\cdot}19D.$$

We therefore cannot rationally double the surface of the threads of a practicable screw, while retaining the same number of threads, except by increasing its diameter in the ratio D to $D\sqrt{2}$ and the diameter of its core in the ratio 0·84D to 1·19D.

We still have to determine what Δ and δ become when we have reduced the number of threads to unity.

b) The reduction to unity of the number of threads, necessary in order to obtain a proper and progressive distribution of P*m*, must be carried out on the previously determined surface if we do not want to exceed the pressure R per unit of useful bearing surface; but on the other hand we must keep the core-diameter δ in which we know that R is not exceeded; now if we put Δ' for the new core-diameter corresponding to the reduced number of threads, δ remaining the same, we have

$$n\frac{\pi}{4}(\Delta^2-\delta^2)=\frac{\pi}{4}(\Delta'^2-\delta^2),$$

and this gives us

$$\Delta'=\sqrt{n\Delta^2-(n-1)\delta}.$$

If then we replace Δ and δ by their previously determined values, and we take n for instance as equal to 7, we obtain

$$\Delta'=2{\cdot}34D.$$

Thus starting with a screw designed normally to have a diameter equal to D, we are led to substitute for it, in order to prevent it from working loose when acted on by rolling loads, a screw with one thread and having a diameter 2·34 times that of the original screw, and in order that this single thread may be sufficiently strong, it must have a pitch equal to the length threaded.

Now this length is

$$\frac{2{\cdot}34D-1{\cdot}19D}{2}=0{\cdot}58D,$$

whereas the length threaded of the original screw was

$$7\times\frac{D-0{\cdot}84D}{2}=0{\cdot}08\times 7D=0{\cdot}56D.$$

Thus this will be a screw having at least the same length threaded and a diameter 2·34 times as great, that is to say, a screw which will be at least *five times as heavy as the original screw* (*see* figures 6 and 7).

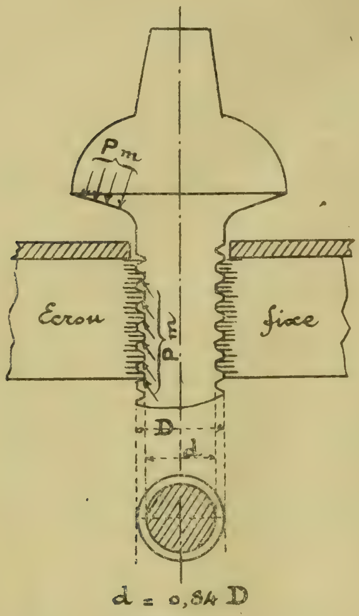


Fig. 6. — Original ordinary screw.

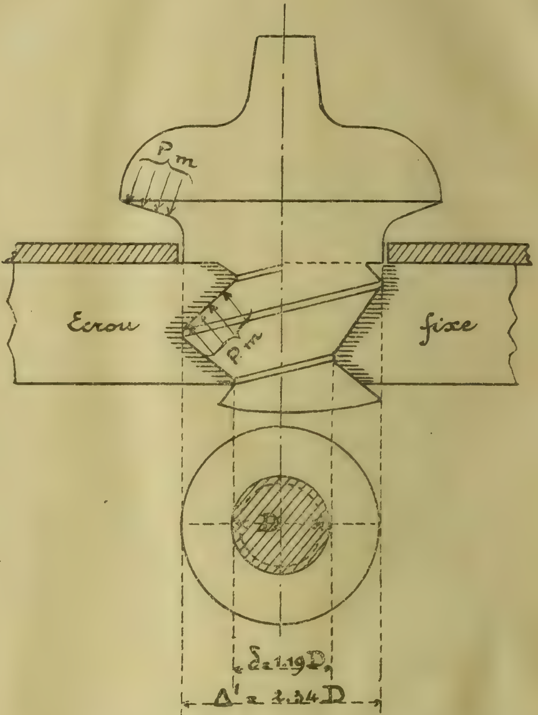


Fig. 7. — Screw modified according to theory.

Explanation of French terms : Écrou fixe = Fixed nut.

This unwieldy object is fortunately only the offspring of a theory; if made however, it would cost at least five times as much as the original screw, and we may state that scarcely one fourth of the metal would be really utilized.

This expensive remedy would be no practical improvement, but as it is the outcome of theoretical considerations, we could not neglect it in this enquiry.

Therefore, instead of rejecting this theoretical solution, we think it advisable, in spite of its costliness, to take it as our starting-point, in seeking a more practical solution, and proceed to remove from it the theoretically useless weight.

We thus enter the field of practical observation, and it is the latter we will now consider.

In this connection we will record the following observations :

1° Wear of the head of the screw, if the screw is movable (this is our case ; but it would equally apply to the nut if the screw was fixed), is bound to occur when the spanner is used to tighten up the screw by turning it.

When pressure begins, the head of the screw only takes against the flange along a single line, just as in the reverse case of a fixed screw and movable nut the latter would only take against the non-horizontal clip-plate by the edge of the bearing surface.

As the pressure P increases, it is clear that the pressure per unit surface readily becomes R, then 2R and so on up to nR; the metal becomes deformed, but even with this deformation, the surface can never become equal to the surface S which would give $\frac{Pm}{S} = R$. We are forced to admit, and observation confirms it, that the head of the screw, where in contact with the flange, has its metal in a crushed state, which makes it easier for the screw to become loosened, and which becomes more marked later on, by the action of the blows which the rolling loads produce.

This defect which is inherent in both screw and nut if they are movable, can hardly be eliminated, as it depends on the shape itself of bodies which are to be turned by the action of a spanner, and therefore, no improvement is possible unless the turning movement and the spanner which produces it are done away with; it is already clear that the defects of the screw are largely due to the spanner, and that the latter can be looked upon as an instrument tending to destroy the screw.

2° The want of absolute accuracy in the manufacture of screws and nuts makes it impossible really to utilize a surface of bearing threads, S, provided, theoretically; irregularities, hollows produced by metal tearing off while the threads are being cut in a mass of more or less homogeneous metal by a tool in more or less good condition, always reduce S and increase R.

If this reduction applied to the whole surface of the threads, that would only be a partial defect, which could be overcome by increasing S when designing the fastening; but this is not the case. A ragged thread, a spot of harder metal, will, when the spanner (always a very powerful tool) is used, deform several threads permanently before the screwing down is completed, and here as before, we see the evil effect of the spanner.

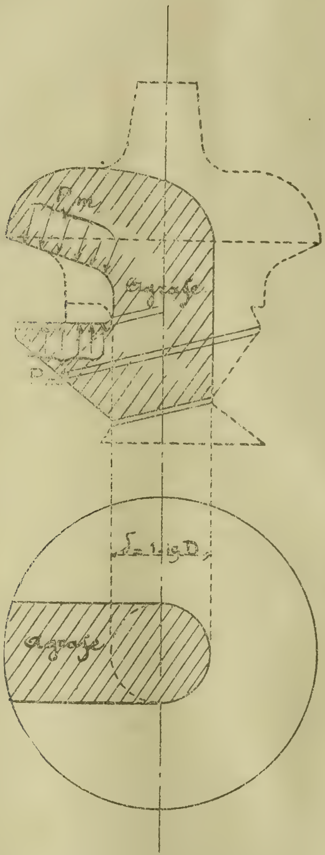
3° Any foreign bodies present between the threads of the screw and the threads of the nut (the result of the want of absolute fit between the screws and nuts now manufactured) become of considerable importance.

Now whether these foreign bodies are introduced accidentally, as for instance sandy dust, or are formed there, as for instance rust by the action of moisture or of electricity, they result in a bad distribution of pressure over part of the surface of the threads. Expansion and contraction due either to sudden change of temperature, or to change of stress produced by the action of rolling loads, then soon produce permanent deformations destroying the screws, and tightening the screws up again by means of a spanner only aggravates the evil.

These remarks show the complicated duty the screw has to perform, owing to the fact that it has, by itself and by the action of a spanner which is the most energetic agent of its destruction, to do two different operations which are nearly always incompatible, namely :

1° To produce pressure ;
2° To maintain pressure.

The cramp forms a true spring.



D being the diameter of the screw as ordinarily designed to resist the total effects of Pm.

Fig. 8. — Screw modified according to theory transformed into cramp, by utilizing only the parts of the "screw" necessary for maintaining the pressure, during the action of unsymmetrical and varying stresses.

Explanation of French term : Agrafe = Cramp.

The screw is expected *to act as a spring* and to press together different parts (rail and sleeper), *but a start is made by deforming this spring* when it is first tightened up.

The screw is thus only an ingeniously designed device for doing two things at once; *but it does both of them badly.*

The efficiency of the screw is very low, and when it is assumed that a useful pressure P*m* has been obtained by pulling the end of the spanner, often there is only a small fraction of this, much of the work of the spanner having been spent in overcoming the friction between the threads.

These observations, which are confirmed every day by the screws and bolts used, lead us logically to a *division in the work* of holding together the rail-fastening.

We do not expect to find in the " screw " itself (a device we cannot improve) the possibility of improving the two different functions it is unfairly expected to fulfil; therefore *giving up one of them, the production of pressure*, we will try to simplify it, by eliminating everything not useful to the other, the maintenance of pressure.

At the point we have arrived at, namely a theoretical screw with its head, its shank and one single thread, there is nothing to hesitate about and in order to be logical we must remove from our theoretical object all that is unnecessary for keeping the pressure constant, and that whatever the consequences may be.

Of the head of the " screw " we only keep the thickness necessary for a good distribution of P*m* for the metal used; instead of a generating line, we will substitute a surface resting on the flange all over, so that we may with certainty have, per unit of surface, R a maximum.

Of the shank of the " screw " we will only keep the thickness of metal necessary for resisting P*m* and its distribution, so that the maximum fibre-stress is R kilograms per unit of surface.

Of the one thread, we will in the first place eliminate the half-thread on the side opposite to the rail, the cause of so much evil; then, with the thickness retained for the head and shank, we adopt the necessary surface which the half-thread had to distribute the pressure P*m* properly. Finally, in order to avoid any slip between the bearing surfaces, we give this remnant of thread a minimum inclination, *i. e.*, zero; this transforms the inclined surface of thread bearing on the thread of the nut into a horizontal surface resting direct on the under-surface of the sleeper, the nut being thus completely eliminated.

To sum up : this simplification of the " screw " is the elimination of the screw as far as its defects are concerned, and its conversion into a simple device having the qualities necessary, namely :

1° A surface bearing on the flange without exceeding R per unit of surface;

2° A surface acting on the sleeper without exceeding R per unit of surface;

3° A core connecting these two bearing surfaces without exceeding R per unit of surface.

This remainder which is incapable of producing pressure by itself, but which has all the properties necessary for preventing loosening, *is a cramp*.

The cramp, the simplification of a screw improved so as to keep fastened, the object of our investigation, is thus the result of selection applied to the two functions of the " screw ", by the omission of one of the two, the production of pressure.

In order to complete our fastening, and to keep it in such a state that it cannot become loosened, we must therefore produce the pressure by means independent of the cramp; we will use for this purpose the simplest and most efficient device : the wedge.

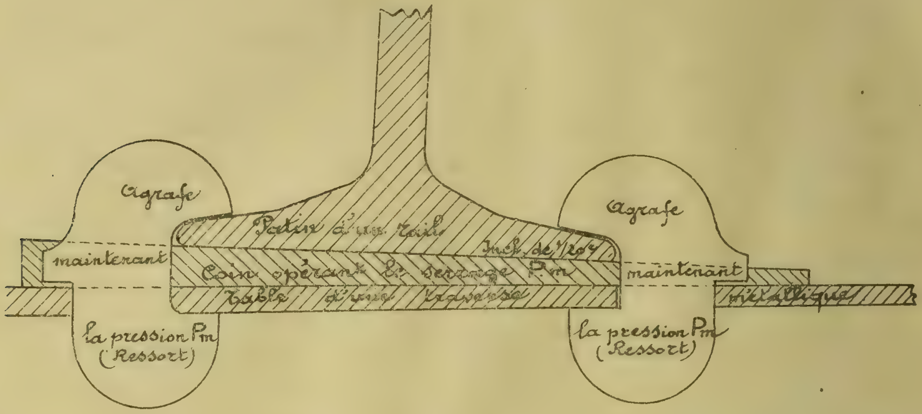


Fig. 9. — Typical fastening. Transformation of the fastening shown in figure 1 and simplification by substituting a wedge for the screw, in order to produce P*m*, and cramps for the screw, in order to maintain P*m*. Division of the work of the screw.

Explanation of French terms : Agrafe maintenant la pression P*m* (ressort) = Cramp maintaining the pressure P*m* (spring). — Patin d'un rail = Flange of rail. — Incl. de $^1/_{20}$e = Inclination, 1 in 20. — Coin opérant le serrage P*m* = Wedge producing the pressure P*m*. — Table d'une traverse métallique = Top of metal sleeper.

We are thus led by reasoning and observation to substitute in the screw fastenings which become loosened objectionably :

1° *The wedge for the screw*, in order to produce pressure;
2° *The cramp for the screw*, in order to maintain that pressure.

In other words, *we substitute " wedge " fastenings* for " screw " fastenings.

And we cannot draw any other conclusion from this investigation, no matter what the apparent contradiction of this result with the existing state of affairs may be.

The use of tracks with " screw " fastenings is so general, and that of tracks with " wedge " fastenings is so limited that this conclusion may appear surprising at first sight, and the following questions of course at once arise :

Why have tracks with wedge fastenings not come into general use?
What trials of them have been made?
What results have these trials given?

These enquiries which we made of the important companies which have applied and tried systems of wedge fastenings, not only do not contradict, but fully confirm the results of the present investigation.

Therefore, to sum up :

Given that railway tracks have to stand stresses of all kinds which are produced by the rolling loads on the rails; that these stresses tend to become greater when the speed of these loads is increased;

Given that the movements of the track, produced by the rolling loads, can only result in unsymmetrical or even symmetrical forces acting in the fastenings, which forces screws cannot resist without expensive maintenance;

We therefore conclude, as a consequence of the present investigation :

That the way to prevent the loosening of the track appears to be to substitute wedge fastenings for screw fastenings.

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THE BREYDON VIADUCT AT GREAT YARMOUTH,

By William MARRIOTT and Theodore Graham GRIBBLE,

MEMBERS OF THE INSTITUTION OF CIVIL ENGINEERS.

Figs. 1 to 16, pp. 25 to 41.

(*Proceedings of the Institution of Civil Engineers.*)

By an act of Parliament dated 6 August, 1897, the Midland and Great Northern Railway Companies were authorized to construct a railway connecting their existing joint-line at Great Yarmouth with the new railway which they, in conjunction with the Great Eastern Railway Company, were then constructing between Yarmouth and Lowestoft.

The principal engineering feature of the line, is a steel viaduct of five spans over the estuary of the River Yare, commonly called Breydon Water. The viaduct consists of three fixed spans of girders of the Whipple-Murphy type, each 169 ft. 10 in. in length over the end-plates, one swing-span, affording two equal openings of 60 feet clear water-way, and one fixed span of 110 ft. 6 in. over the end-plates, figures 1. A space of 3 inches was allowed between the end-plates of adjacent girders, to provide for expansion and for possible discrepancies between the triangulation measurement and the shop measurement of the girders. The determination of the exact location and skew of the swing-span involved a considerable amount of work. A survey of the whole river-bed was made for about $^1/_2$ mile on each side of the site, and was plotted to a large scale. The river takes a right-angle bend on the Norwich side of the bridge, almost immediately above the swing-span. A line representing the track of a vessel necessary to negotiate this bend was laid down on the plan, and from it the exact angle of the skew was determined. On viewing the site of the channel at low water, from the turret of the bridge, it is immediately apparent that the site and skew are correct and could not be improved upon.

Foundations. — In order to obtain data for designing the foundations, trial borings were taken close to the sites for piers Nos. 3, 4 and 7. These were carried to depths of 83 feet, 82 feet, and 100 feet respectively, below the surface, figures 5. The beds passed through are the alluvial or estuarine deposists, and it has been estimated that these, with perhaps some Pliocene deposits, extend down to about 150 feet below ordnance datum, and at this depth the London clay would probably be struck. The diameter of the borings in each case was 4 inches, and the driving was done with a 400-lb. monkey, the drop being 1 foot to 2 ft. 6 in.

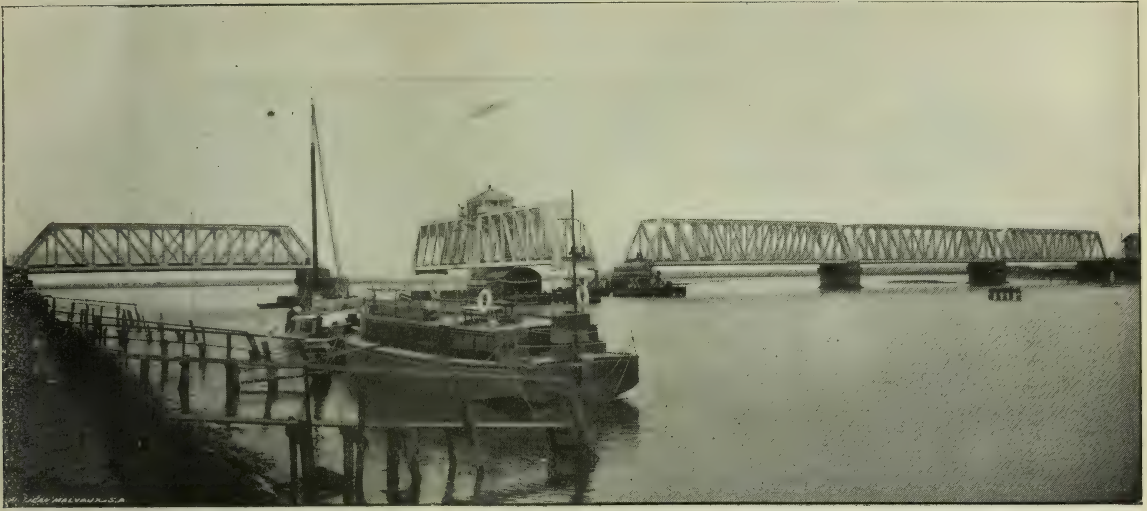


Fig. 2.

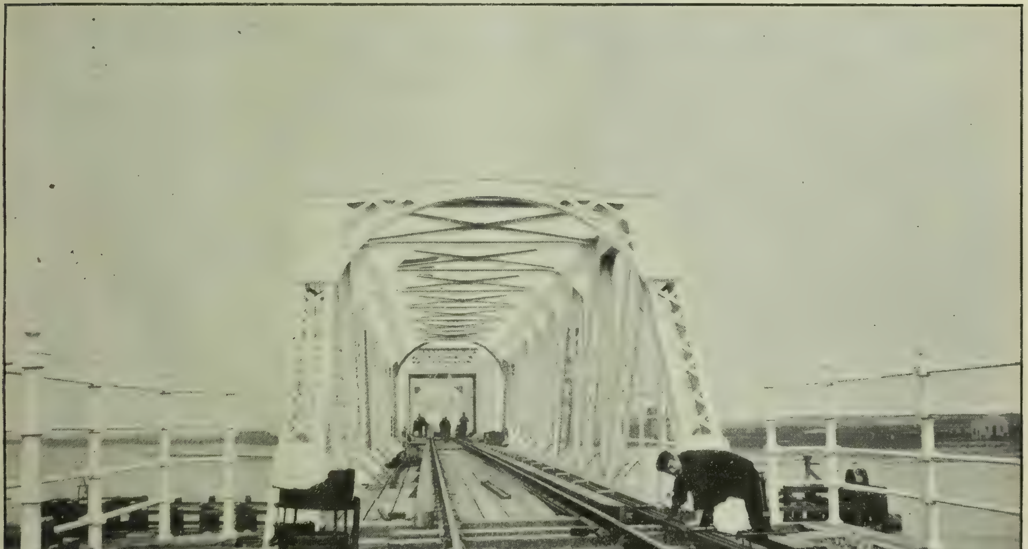


Fig. 3.

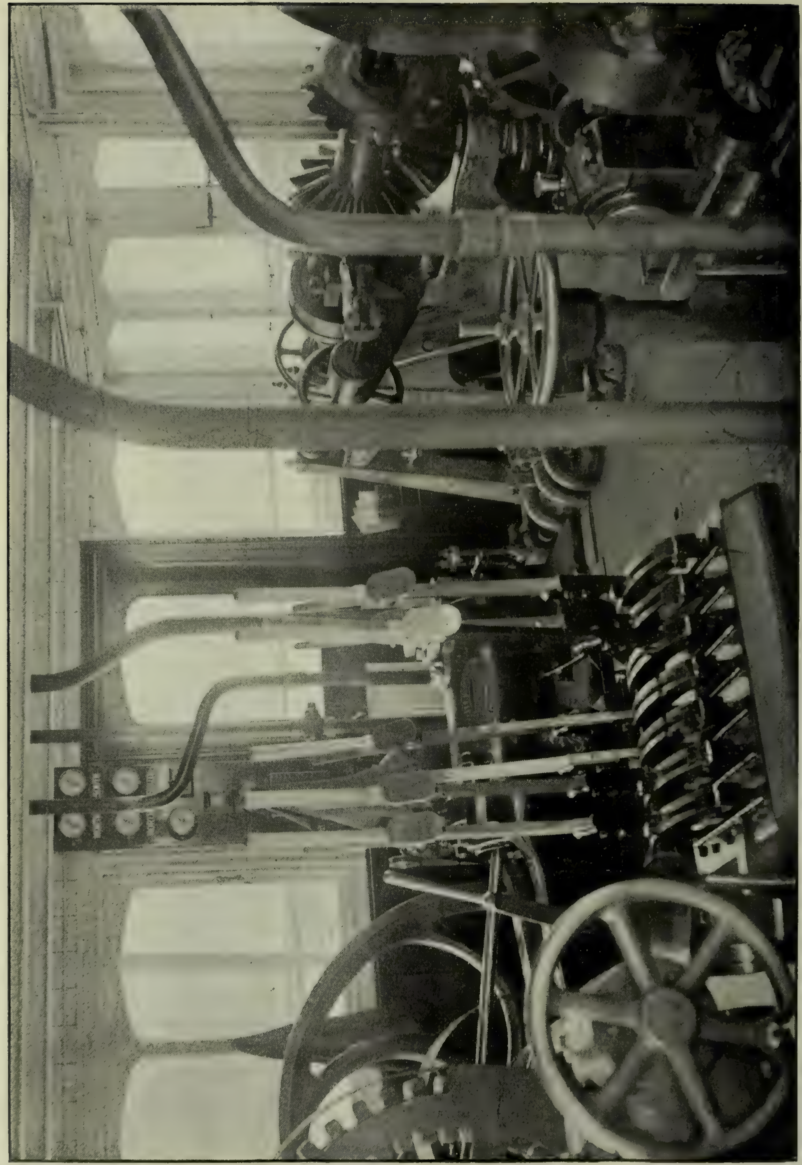
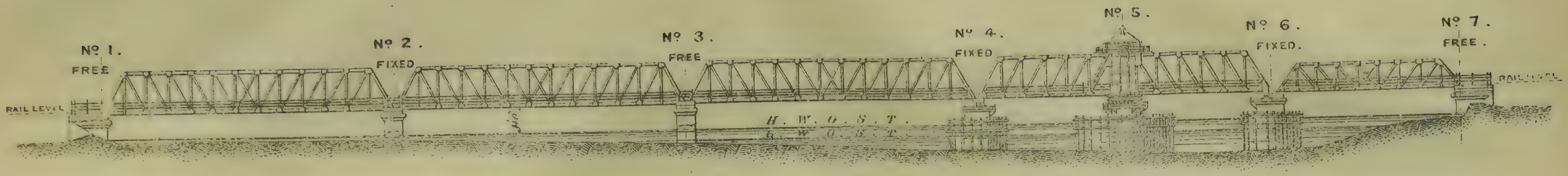
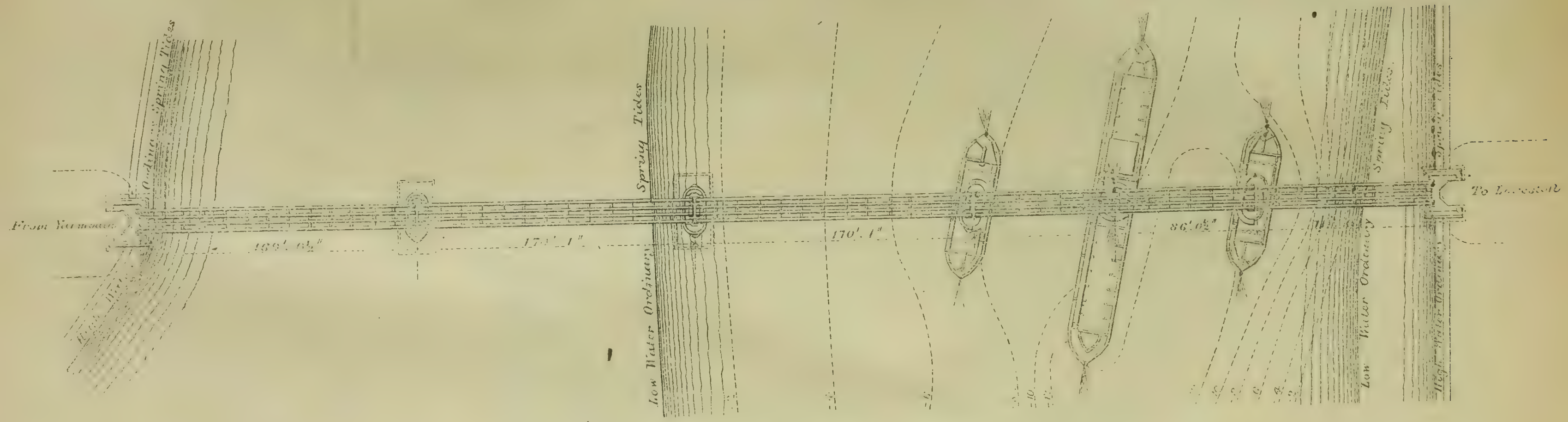


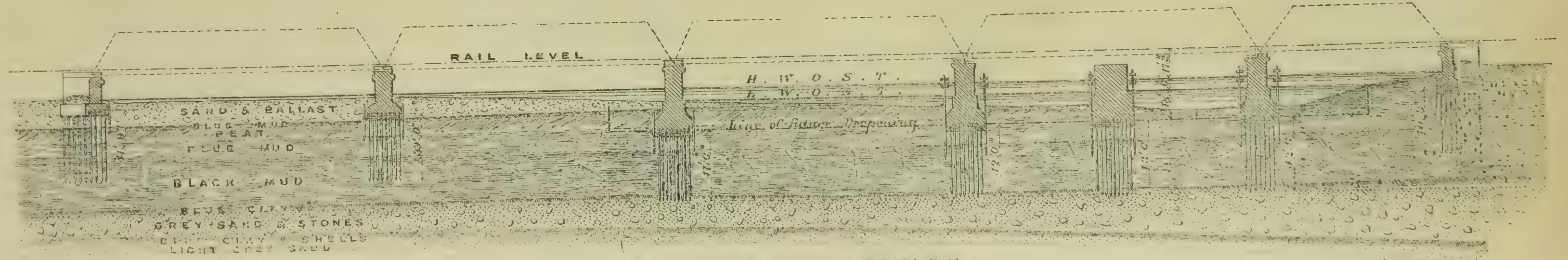
Fig. 4.



ELEVATION.



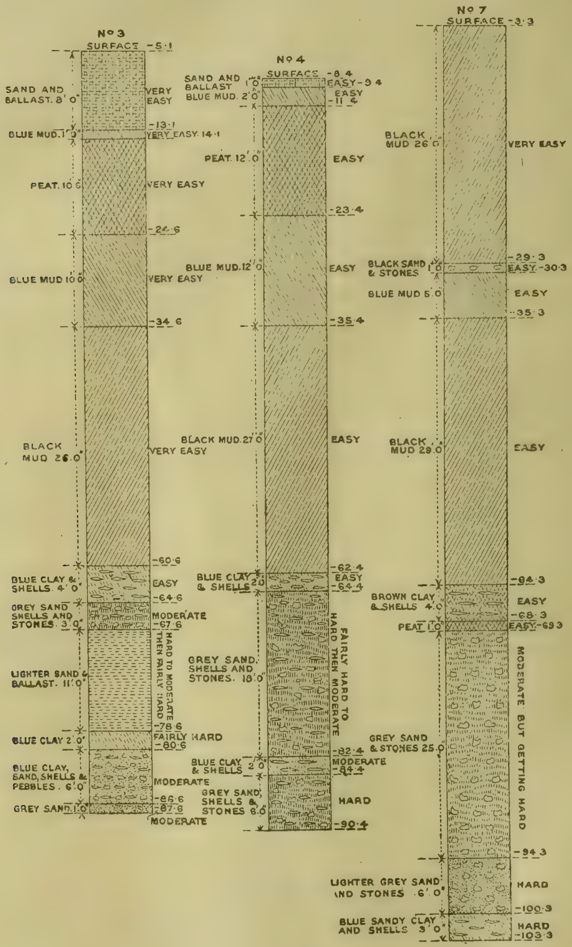
PLAN.



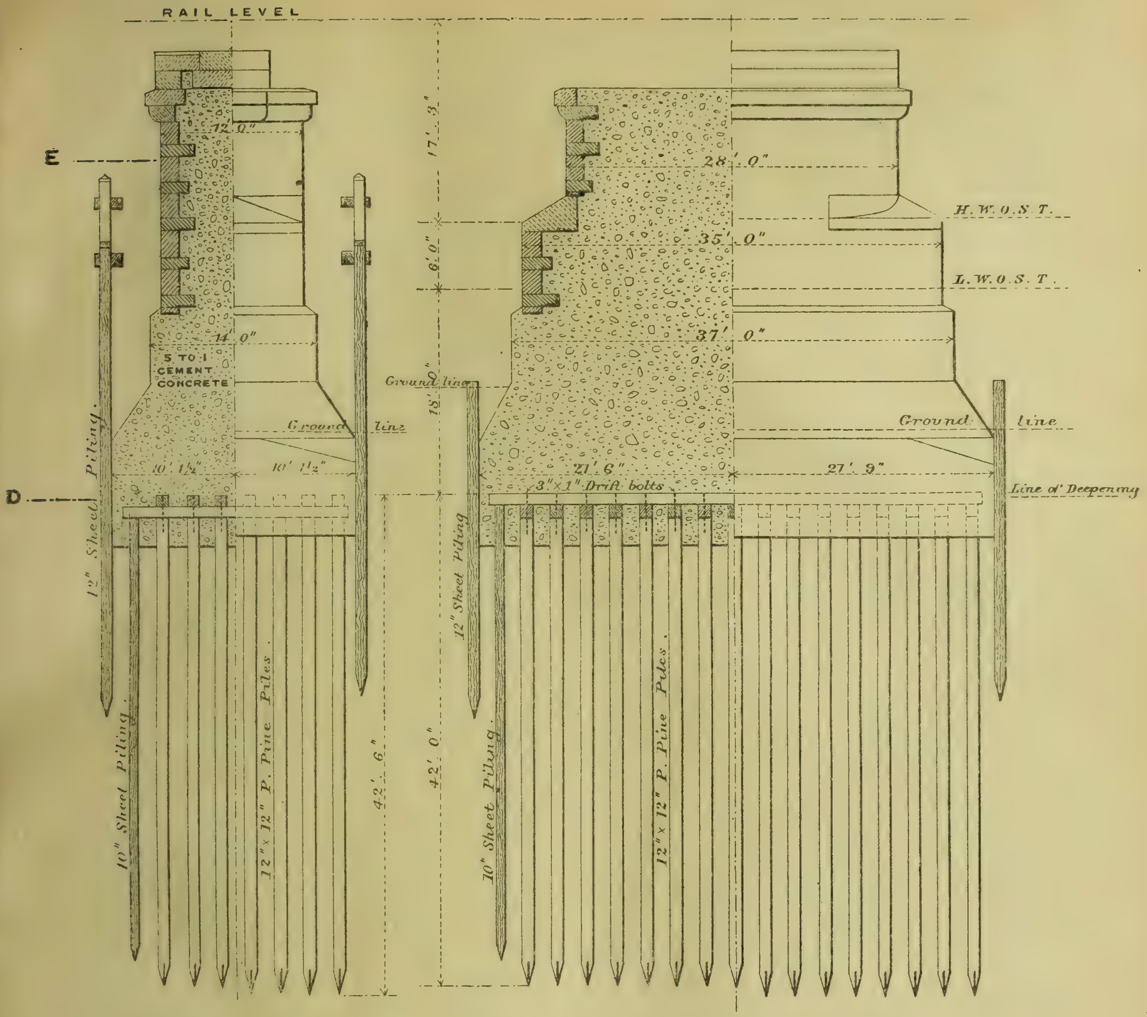
LONGITUDINAL SECTION.

Figs. 1. — Breydon viaduct : Great Yarmouth.

It will be seen that the river mud gradually stiffens down to a depth of 60 feet below low-water level, where it may be termed a weak blue clay, after which beds of clay and sand alternate, so that caissons or cylinders would have been impracticable. If caissons had been adopted, they would have required a depth of about 100 feet below rail-level, and the weight of the concrete filling inside them would of itself have been too great for the foundation without any external load. It was, therefore, decided to use a pile foundation, in which all timber-work would be submerged and therefore practically imperishable, figures 6. By this means the height of the masonry was limited to about 45 feet, and the weight was brought well within the supporting-power of the piling as ascertained by the driving of a trial pile.



Figs. 5.

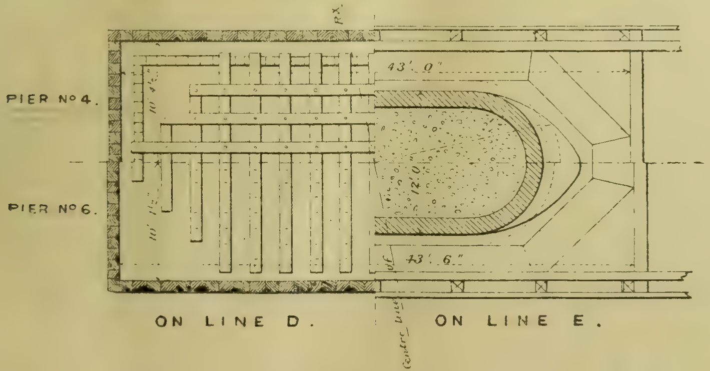


Pier No. 4.
Cross section.

Pier No. 6.
(East end.)
End elevation.

Pier No. 4.
Longitudinal section.

Pier No. 6.
Elevation.



Plan.

Figs. 6.

The weight which each pile has to support, neglecting any assistance from the clay between the piles, is as follows :

Pier.	Tons.	Pier.	Tons.
No. 1	6·81	No. 5	10·51
— 2	9·18	— 6	9·83
— 3	12·21	— 7	9·53
— 4	9·43		

The piles were of American pitch-pine, driven inside a coffer-dam of close pile-work without puddle, strutted and braced from side to side. The coffer-dam piles were specified to be tongued and grooved, but the contractor preferred to take the responsibility of driving them ungrooved, and afterwards employing a diver to caulk them. Some difficulty was experienced in making the dams water-tight, but no serious mishap occurred. The piles were specified to be driven by a 30-cwt. power-hammer, until the aggregate set from six blows at a fall of 5 feet did not exceed 1 $^1/_2$ inch. Although a trial pile was driven, it was apprehended from the result of the borings that there would be considerable variation in the supporting-power of the piles, and where required provision was made for increasing the number. In some of the piers, extra piles were driven, thus compacting the piled area as well as supplying additional support; in the case of the pivot-pier and its two adjacent piers, a complete internal coffer-dam was driven, and all these extra piles were utilized as additional support for the masonry. The variation in the load per pile is approximately that of the calculated average supporting-power. The weight of the hammer was 23 cwts. and the average fall was 7 $^1/_2$ feet. The aggregate set from the last six blows varied between 1·8 inch and 4·4 inches. When the calculated supporting-power of the number of piles shown on the drawing fell below that required by the specification, more piles were driven, in preference to scarfing and driving deeper.

The heads of the supporting-piles were sawn off at the bottom of the dam; those of the coffer-dam were bored from the inside, plugged, and broken off. The heads of the piles were secured with a nest of concrete about 3 feet in thickness and capped with a grid of whole timbers, forming a platform upon which the masonry was carried up. The hearting of the piers is formed of good cement-concrete, gauged 5 to 1. The specified tensile test of the cement was 350 lb. per square inch, but the average resistance was about 440 lb. per square inch. The facing of the piers is of Staffordshire brindle-bricks, the cutwaters and coping being of Bramley Fall stone. The girder bed-stones and the roller-path of the swing-bridge are of Cornish granite. The timber protection of the swing-span piers is of more substantial character than would have been requisite for the existing river traffic, but was considered necessary by the Haven Commissioners in view of the possible development of the water-way by dredging. The heads of all the fender-piles have cast-iron galvanized caps.

General design of superstructure. — The three longer fixed spans are precisely similar, are 24 ft. 2 in. in depth at the centre, and have a camber of 6 inches. The ratio of length to depth, 7 to 1, was determined as the most economical after considerable calculation, the question of greatest economy being affected by the practical consideration of least waste in using standard sections. A ratio of 8 to 1 was found to involve about 10 per cent more material. The swing-span is of the same depth as the three longer fixed spans. A shallower girder would have been somewhat more economical but would not have been so convenient for the arrangement of the turret, and would have been less sightly in general outline. The shorter fixed span at the

Lowestoft end is necessarily shallower, but was made, as far as possible, of similar general appearance. A plate-girder would have been quite practicable for this span, but would have involved more material. A comparative calculation was made of the cost of the whole structure with short or with long spans, taking as an alternative six plate-girder spans in place of the three longer fixed spans; the saving in the cost of the superstructure with short spans was found to be greatly overbalanced by the extra cost of the foundations. The position of the swing-span being fixed by the Haven Commissioners, it is believed that the dimensions selected are the most economical that could be chosen.

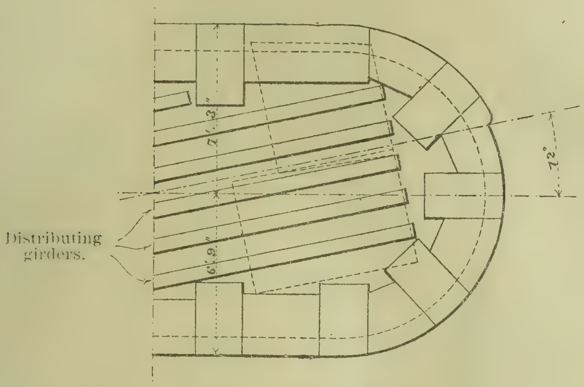


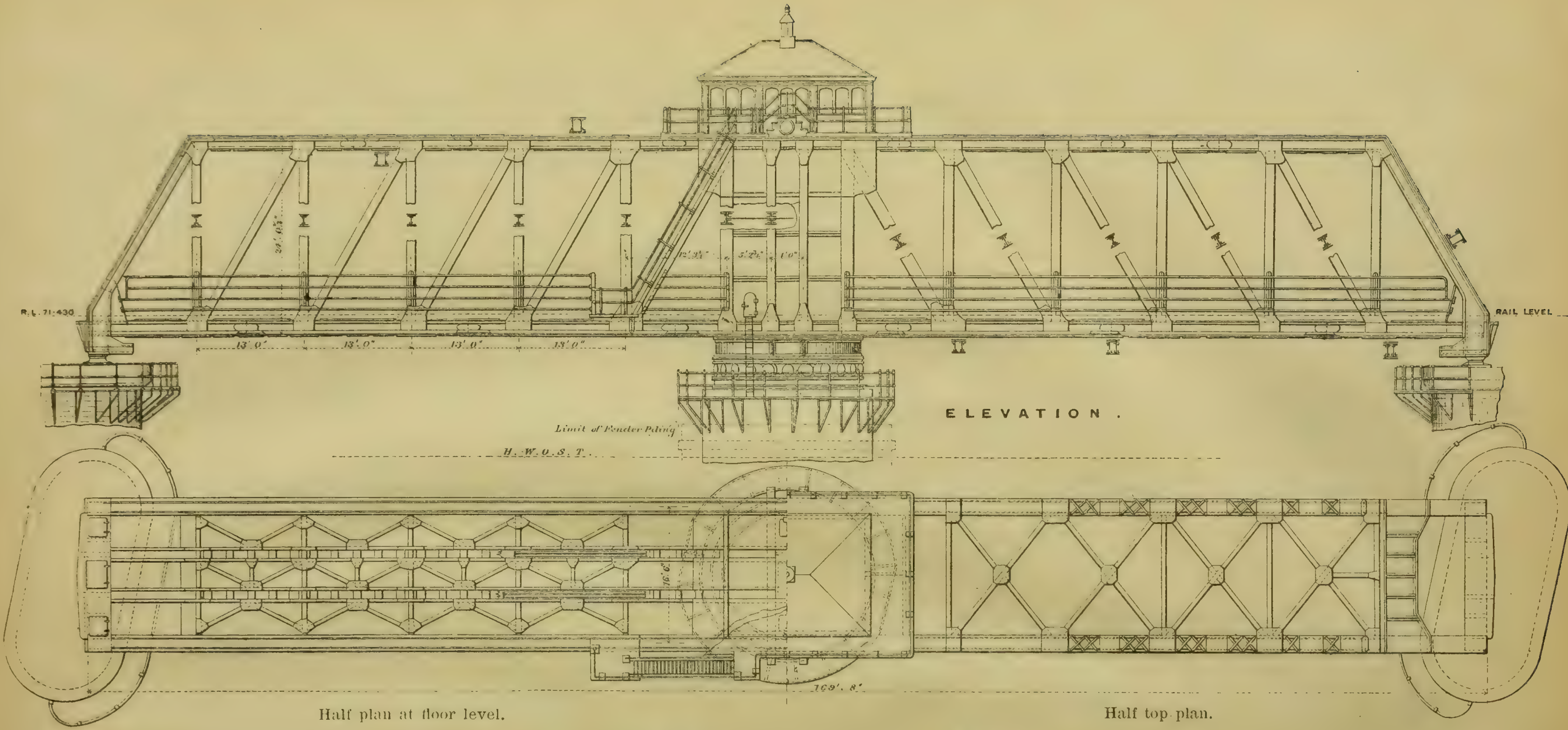
Fig. 7.

In making the calculations for the girders, the rolling-load assumed, was that of a train of the heaviest engines of the parent companies, three of which can come upon one of the longer spans. From this was deduced what may be termed the " blanket " load, that is, the uniform rolling-load which will cover the maximum bending-moment in any position of the wheels. The maximum static effect close to one abutment being ascertained by placing a pair of the heaviest driving-wheels, say, 6 inches from it, the " blanket " load is given by thee quation $W = \frac{2M}{C - 0{\cdot}25}$, in which W denotes the equivalent uniform load in tons per foot run, M denotes the maximum possible bending-moment in foot-tons at 6 inches from the end, and C denotes the half-span in feet. Allowance for impact was made by the Wœhler-Weyrauch formula.

Main girders. — The main girders are of a single triangulation, having the central panel in the fixed spans counterbraced, and in the swing-span of solid plate, figures 8. The panels have the diagonals arranged as tie-struts, with extra allowance of material for alternating stress where such stress is possible. The web-members were arranged with the principal plates in the same plane as the vertical flange-plates, to secure as far as possible axial stresses, the attachment being in all cases by means of double cover-plates, and the spaces being packed solid.

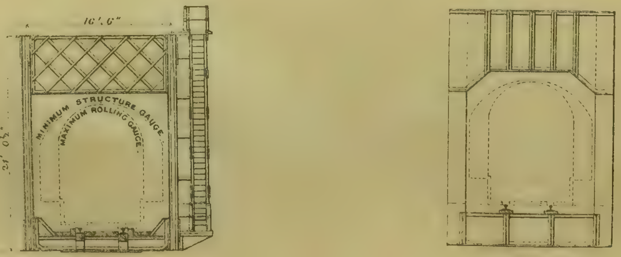
The wind-pressure allowed for was 300 lb. per lineal foot on the lower flange, and 150 lb. per lineal foot on the upper flange. In the case of the swing-span, however, the lateral bracing was made considerably stronger to provide for shock when latching.

The flooring is composed of cross-girders and rail-bearing girders with longitudinal timbers



Half plan at floor level.

Half top plan.



Cross section.

End elevation.

Figs. 8.

of Karri-wood. The cross-girders have triangular ends, forming one piece with the gusset, and constituting, together with the upper wind-bracing, a closed frame of great lateral stiffness. The rail-bearing girders are of the same depth as the cross-girders, and, in addition to their web-attachment, have flange-covers traversing the cross-girders, producing complete continuity of stress and a distribution of the live-load over several cross-girders.

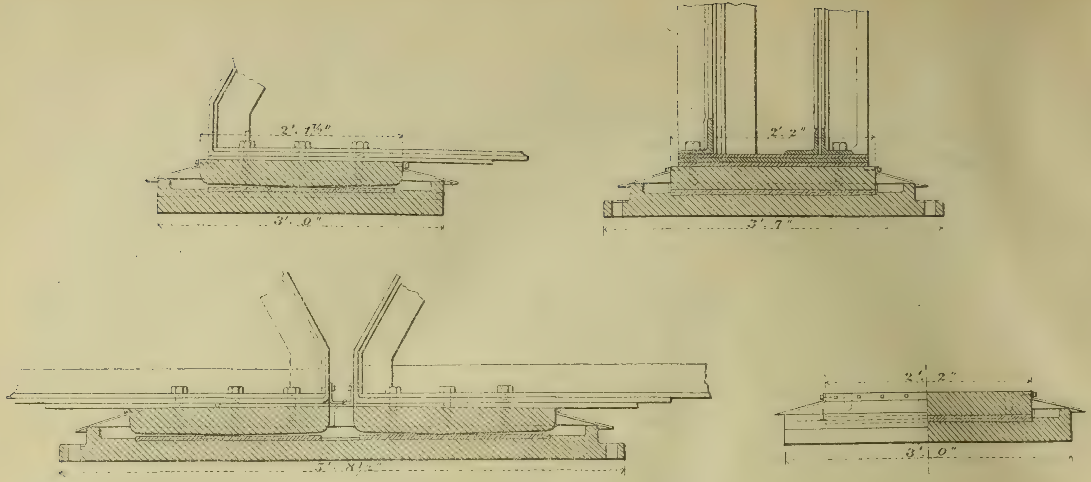
The following provision has been made for the expansion of the girders. A steel bed-plate casting is bolted to the stonework. A gun-metal strip is recessed into this $^3/_8$ inch and fixed with twenty-four $^3/_4$-inch gun-metal screws. This strip has a flat surface for a distance of 2 $^1/_2$ inches on each side of the centre, and then tapers 1 in 152 downwards. On this rests the rocker, of cast steel, fixed to the underside of the girder. This has a level surface, bearing on the gun-metal strip, for a width of 1 inch on each side of the centre, and then tapers 1 in 176 upwards. To retain the lubricant of tallow and oil, the bed-plate has a raised rim all round, and a $^1/_8$ inch copper cap prevents dust, etc., getting in, figures 9. Up to the present time, very little expansion has been noticed. Provision has also been made for the expansion of the permanent-way at the same piers as for the girders of the three long spans. The rails are spliced vertically along the centre for 7 $^1/_2$ inches, and are allowed 1 $^1/_2$ inch clearance, figures 10. They have five slotted holes on each side and one through the splice. The spliced ends are held in position by lengths of angle fish-plates fixed to sole timbers, clearance being allowed between the adjacent angle fish-plates, figures 11 and 12. The girders are fixed at piers Nos 2, 4 and 6, and the expansion arrangements are provided at Nos. 1, 3 and 7, figures 1.

Scarcely any hand-riveting was done, either at the works or at the site. The bulk of the riveting was done with the De Bergue pneumatic tool. In places where this was not practicable, the Boyer percussion-machine and pneumatic holder-up were used. The compressor was a Tangye machine working up to a pressure of 100 lb. per square inch. In designing the riveted joints, no assistance from the " bite " of the machine or the contraction of the rivet-shank in cooling was relied upon, but numerous experiments were made at the Department of Tests of the Midland Railway, by the courtesy of Mr. S. W. Johnson, M. Inst. C. E., to determine the relative frictional resistance of hand-riveting, Boyer percussion-riveting, De Bergue pneumatic riveting, and hydraulic riveting. Applying the result to a tension-joint of the 108-foot fixed span, the different methods of riveting gave the following relations between the ultimate strength of the group of rivets and that of the bars themselves :

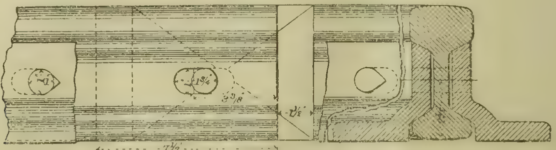
Hand-riveting	19 per cent.	De Bergue riveting	16 $^3/_4$ per cent.
Boyer riveting	15 $^1/_4$ —	Hydraulic riveting	33 —

The hand-riveting of the experiments was done by a first-class gang, which is difficult to obtain on erection-work. Hydraulic riveting was of course impracticable.

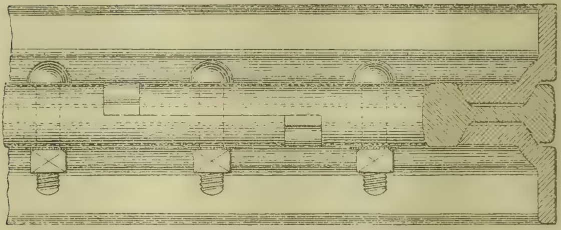
Turntable and rack of swing-span. — The centre-pivot is of cast iron, and weighs about 7 tons. The cap from which the whole span is suspended is of cast steel and weighs about 3 tons. Between the cap and the pivot-head is a pair of steel bearing-plates having two concentric V-shaped grooves, in which sixty-nine hardened steel balls, 2 inches in diameter, supply the bearing. The V grooves are arranged to give four points of contact to each ball, being the extremities of the diameters of two circles forming the ends of a frustum of an imaginary cone having its apex in the centre of the pivot and its axis horizontal, thus giving true rotary motion and avoiding slip. The cap carries the bridge by means of eight suspension-bolts of crucible steel, 4 inches in diameter, the girders resting on a pair of very heavy fish-



Figs. 9.

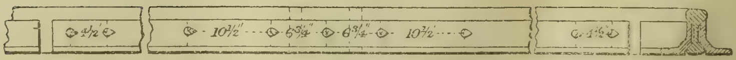


ELEVATION



PLAN

Figs. 10.



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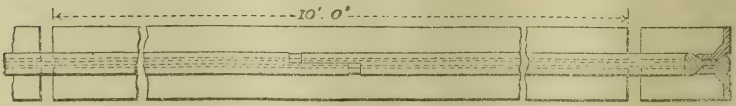

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Figs. 11.

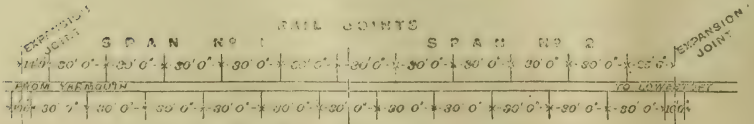


Fig. 12.

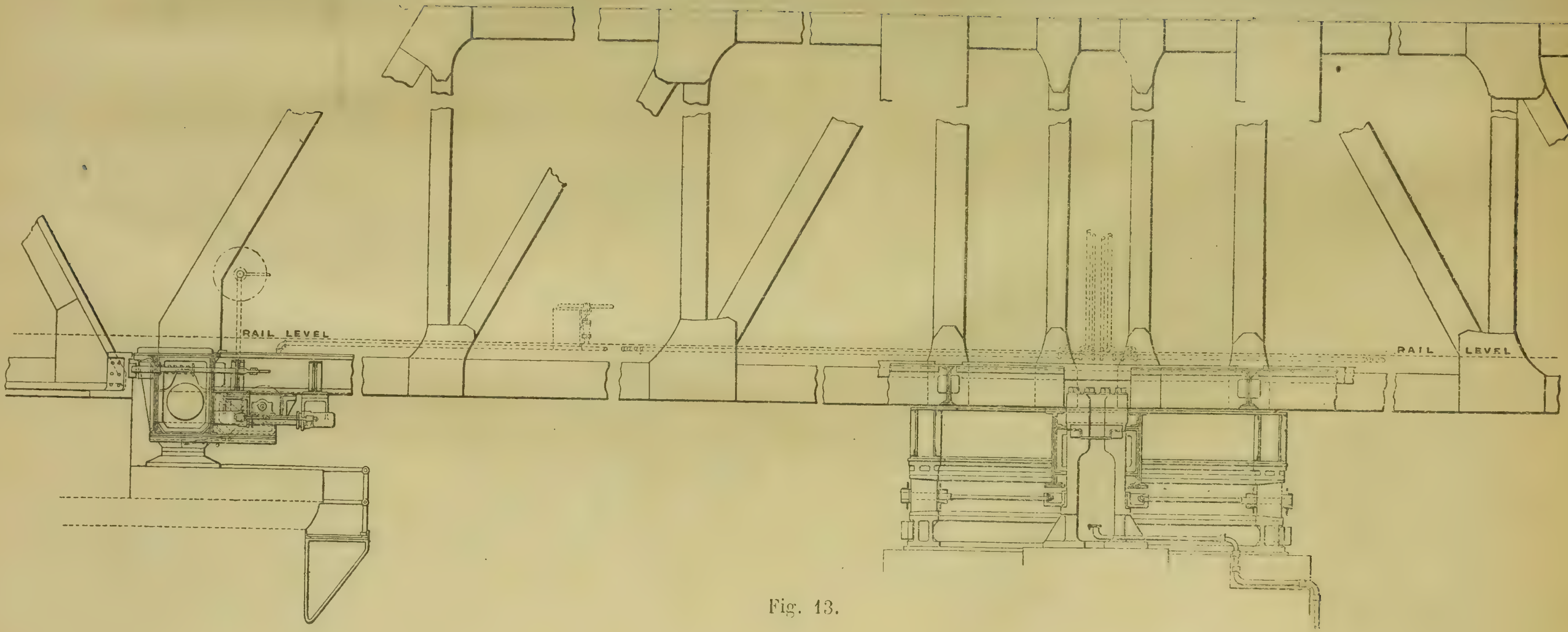
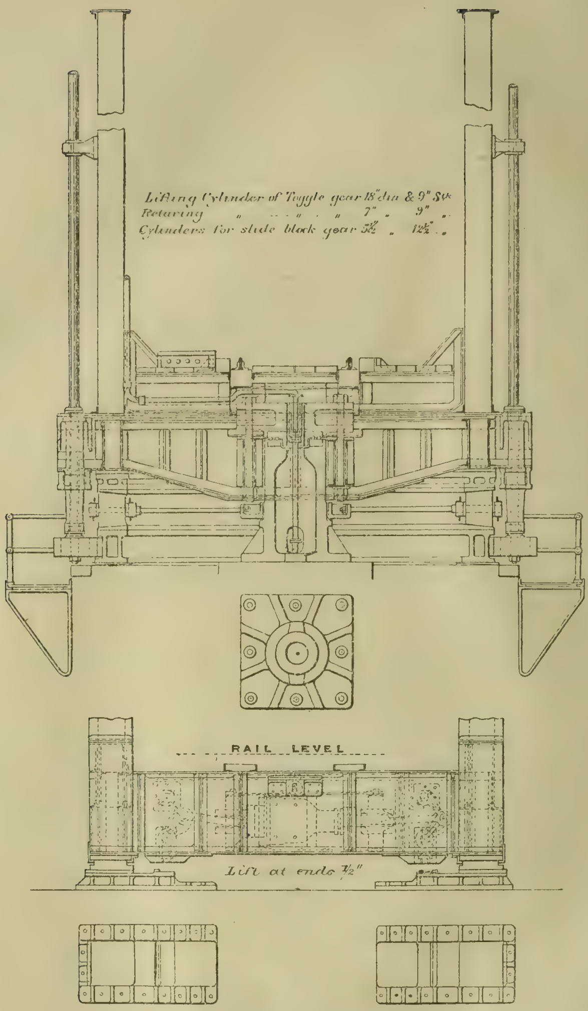
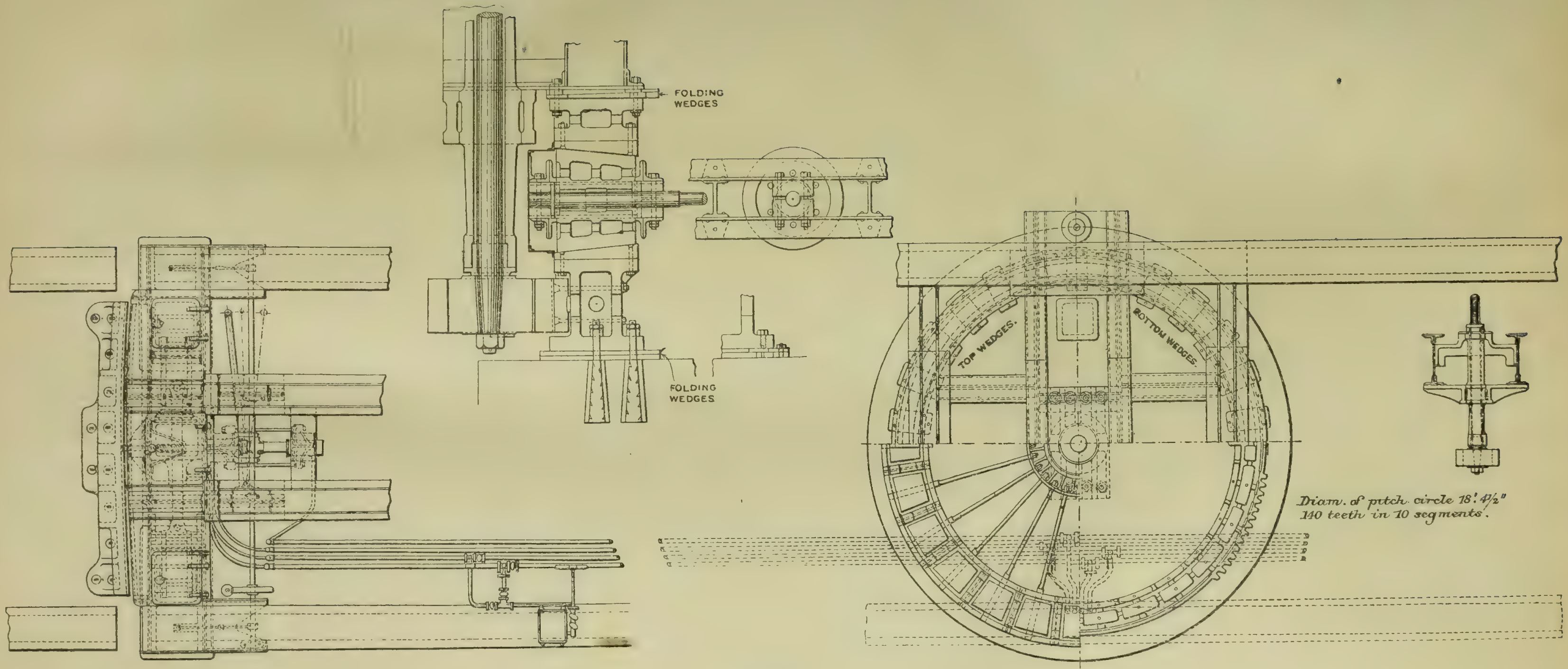


Fig. 13.


Lifting Cylinder of Toggle gear 18" dia & 9" Str
Returing " ... " " 7" " 9" "
Cylinders for slide block gear 5½ " 12½" "
RAIL LEVEL
Lift at ends ½"

Figs. 13 (*following*).

bellied girders similar to those of an engine turntable, figures 13. Except when closed, the swing-span is supported almost entirely on the ball-bearing, the live ring and spider-frame merely acting as guides and checks. The live ring, on the other hand, is capable of taking the whole weight of the bridge, and can be made to do so should it be necessary to carry out repairs to the centre-pivot while the bridge is in operation. In ordinary working, the weight is so divided between the live ring and the ball-bearing, by adjusting the suspension-bolts, that the least resistance is offered to the swinging of the bridge, and this is found to be when practically the whole weight is carried on the centre-pivot. The weight is distributed over the live ring by a circular steel box-girder. The roller-path of the live ring is composed of a pair of circular

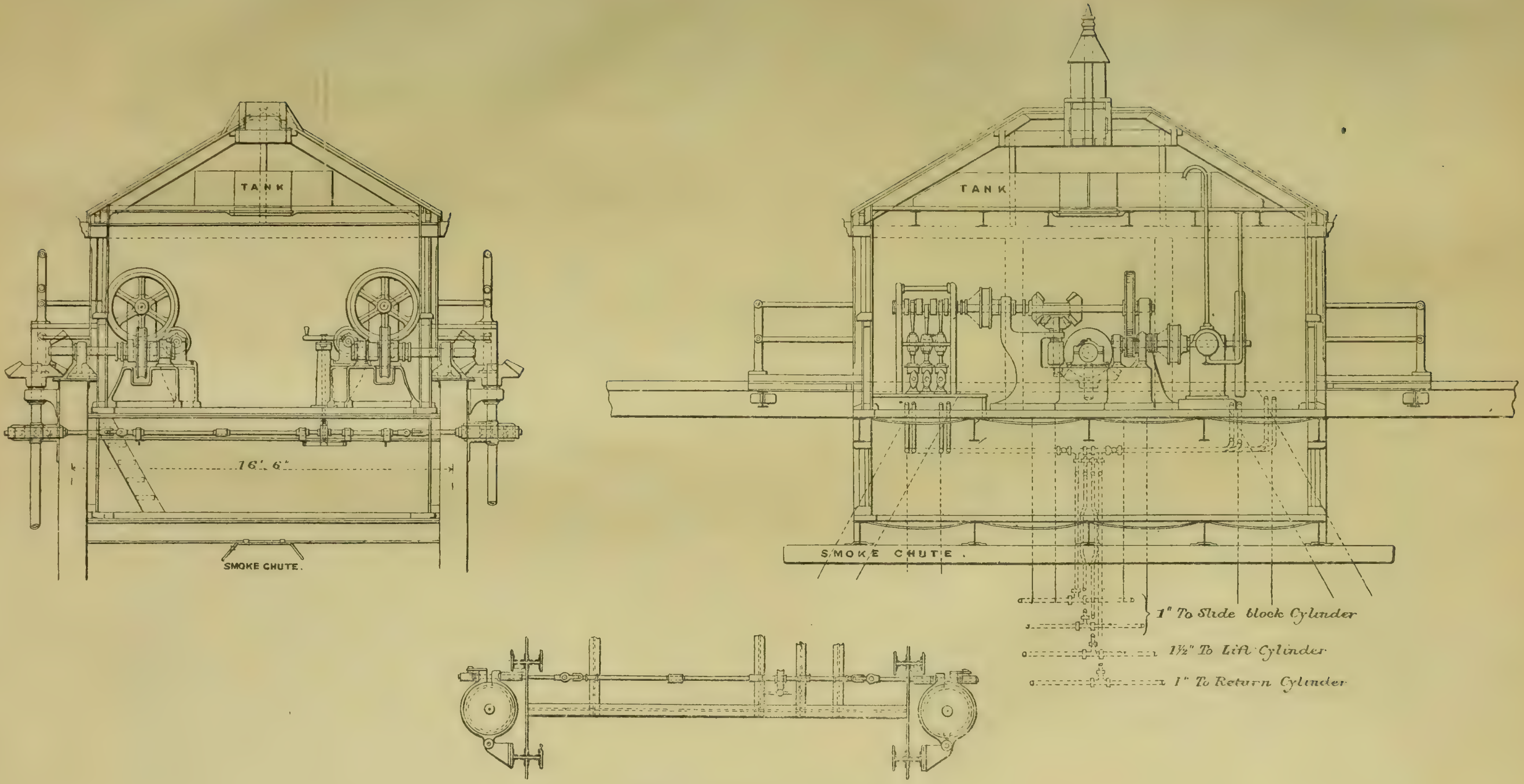

FOLDING WEDGES
FOLDING WEDGES
TOP WEDGES.
BOTTOM WEDGES.
Diam. of pitch circle 18'. 4½"
140 teeth in 10 segments.

Figs. 14.

cast-iron girders, each in six segments, having cast-steel plates as roller-tracks, made to the inclination of the rollers, the plates being adjusted to the true level by means of folding-wedges, figures 14. The lower path casting carries a rack of twelve cast-steel segments having 144 cycloidal teeth, 10 inches in breadth, the pitch-circle being 18 ft. 4 $^1/_2$ in. in diameter. The live ring is composed of twenty-four cast-steel rollers, being frustums of cones 1 ft. 3 in. in length and 1 ft. 6 in. in mean diameter, turned and bushed with gun-metal. The spindles at the outer ends are carried in cast-iron clip-blocks between two angle-steel stay-rings. The inner ends are carried by a cast-steel spider-frame bushed with gun-metal to receive the pivot. A detachable snow-screen of thin plate is fastened in the winter months to the stay-rings of the spider-frame to protect the rollers from becoming clogged.

Turning machinery. — The two pinions operating on the rack carried by the lower path casting, are of cast-steel machined all over, the teeth being machine-cut from the solid. The main vertical shafts are of steel, 5 inches in diameter, turned all over and tapered at their lower ends to take the pinions. The fish-bellied carrying-girders project on either side of the circular box-girder, each end carrying a cast-steel bracket which supports the main vertical shaft, and also a cast-steel sleeve through which the end of the shaft passes, thus giving good support to the pinion. In addition to the lower bracket which carries the weight of the main shaft, there are two supporting-brackets of cast iron, with caps and bushed with gun-metal, one at the top and the other intermediate. Directly under the top bearing on each main shaft there is fitted a friction-brake for checking the motion of the bridge at the moment it is being locked, or, in case of heavy winds, which are very frequent, to steady the bridge, and also to keep it locked when open for river traffic. The brakes are worked from the turret by means of a hand-wheel and a worm- gearing with a worm- wheel on a horizontal shaft under the turret-floor, which operates the brake-straps of each shaft by means of right- and left-hand screws, figures 15. The power for turning the bridge is furnished by an Otto gas-engine of 11 brake-HP. working at 200 revolutions per minute, the speed being reduced by spur-, worm- and bevel-gearing to 1·55 revolution per minute at the main vertical shafts. Reversal of the direction of turning is effected by means of a set of mitre-wheels. The worm-wheel is provided, on each side of its boss, with claws into which gears a corresponding claw-clutch (of the crown-wheel type) sliding on a key on the shaft, and either clutch is brought into gear according to the direction of turning. In the event of the wind catching the bridge and causing it to overrun the engine, the clutch simply slips out of gear. The first-motion shaft is connected to the engine crank-shaft by a friction-clutch, which allows of the load being put on gradually, thus avoiding shock. By means of a friction-clutch at its extremity, the counter-shaft is also coupled to the three-throw hydraulic pumps for supplying hydraulic pressure to the lifting and slide-block cylinders, figures 15.

Lifting and slide-block gearing. — The end lifts and slide bearing-blocks are operated by hydraulic rams, controlled from the turret. The lift- and return-cylinders are in one casting of special cast iron, and are 18 inches in diameter by 9 inches stroke and 7 inches in diameter by 9 inches stroke respectively. The rams are cased with gun-metal, and are coupled together by two steel rods, 6 inches by 1 inch in cross-section. The thrust-block is faced with a hardened steel plate, one edge of which is bevelled and coincides with a bevelled strip on the bed-block, which ensures correct alignment when lifting. The stroke of each ram is governed by the other, each in its turn acting as a stop for the other. The length of the thrust-blocks is so arranged as to just lift the ends of the bridge clear of the bearing-blocks when the ram is at the end of its stroke.



Figs. 15. — Plan of brake.

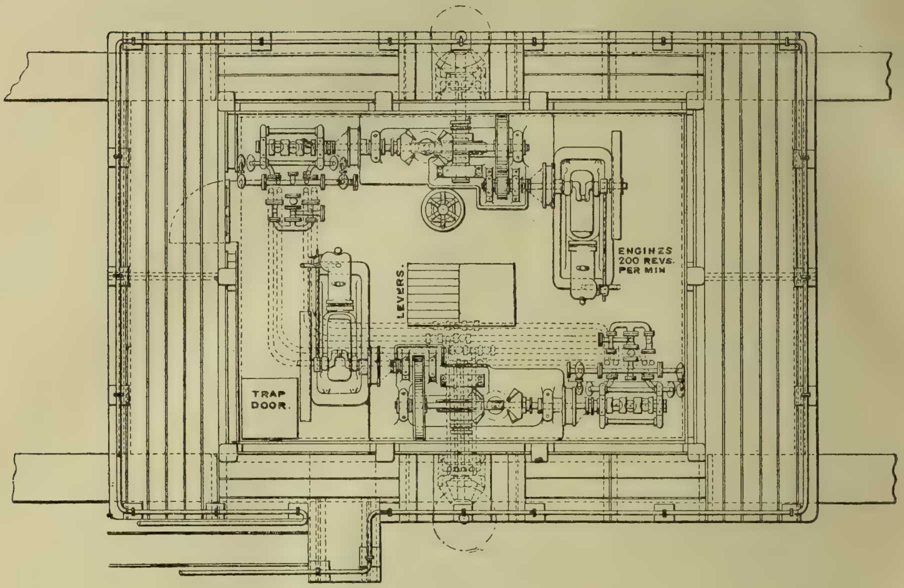
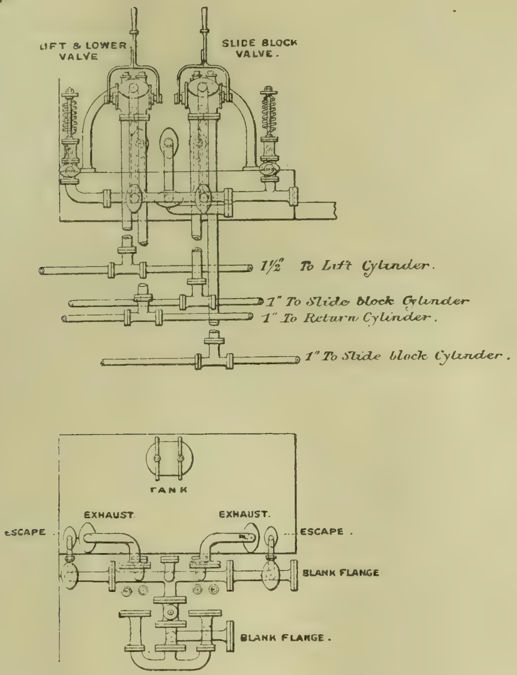


Fig. 15 (*following*).

This gear is carried in the box-girders attached to the ends of the main girders. Another pair of hydraulic cylinders, 5 $^{1}/_{2}$ inches in diameter by 12 $^{1}/_{2}$ inches stroke, is provided for withdrawing and returning the bearing blocks, which are carried in angle-slides. The hydraulic pressure-mains are of iron, lap-welded, 2 inches in internal diameter between the working-valves and rail-level, thence 1 $^{1}/_{2}$ inch in diameter to the lifting-cylinders, 1 inch in diameter to the return-cylinders, and 1 inch in diameter to the cylinders for operating the slide bearing-blocks. The glycerine mixture, containing 10 to 50 per cent of glycerine, according to the temperature, is pumped directly into the pipes at a working-pressure of 600 lb. per square inch, and escape-valves are provided so that when the working-valve is closed, with the pumps still working, the mixture returns to the cast-iron tanks provided directly under, and forming a base for, the pumps, figures 16. As the situation of the bridge is very exposed, gas jets are provided at all important points for warming purposes. The bridge is locked, when in position for a train to pass over it, by a spring lock-bolt 4 by 3 inches in cross-section, made of steel, with the working-faces hardened. When the bridge is swinging into the closed position, the lock-bolt strikes on an inclined plane provided on the curb-castings, which depresses it, the recoil of the spring effecting the locking when the bridge is in position. The lock-bolt is withdrawn from the turret by means of a lever and connecting-wire. The curb-castings are heavy castings placed at the ends of the fixed spans, next to the swing-span, to support the ends of the rails.

The operations for opening the bridge were specified to occupy not more than 3 $^{3}/_{4}$ minutes from the time the lock-bolts were withdrawn, to the time the bridge was brought to a stand at right-angles to the railway. The operation was found to be capable of being performed in about four minutes, the time taken depending upon the skill of the operator in the turret and upon the eather conditions.



Figs. 16. — Enlarged view of valve gear.

Emergency-gear. — In case of a breakdown in the machinery, a complete emergency-gear is provided for operating the bridge; a crab is placed at one end of the centre-pier fendering, and a wire rope is carried from it round a bollard to a shackle at the end of the main girder, for swinging the bridge. The end lifts are performed by four 100-ton hydraulic jacks. In the case, however, of only the turret-machinery being disabled, the hydraulic rams in the end box-girders can still be operated, for lifting and lowering the ends of the bridge, by hand-pumps provided near the ends of the bridge, at rail-level. The working of the slide-blocks is also provided for by a hand gear, consisting of a worm and worm- wheel worked from rail-level by a removable crank-handle and a pair of bevel-wheels.

Gas and Water-supply. — The gas-pipe for supplying the engines in the turret is laid across the bed of the channel, and consists of a copper pipe, 2 inches in internal diameter, cased in a cast-iron pipe 9 inches in diameter, to prevent the small pipe being caught by an anchor. It discharges into the bottom chamber of a cast-iron well 3 feet in diameter, which extends above high-water level. A pump is provided in the well for removing any water which may accumulate in the bottom chamber. Should the pipe across the channel fail, recourse may be had to another pipe which runs along the swing-span at rail-level and discharges into a gas-holder of 500 cubic feet capacity, fixed on the centre-pier fendering, which is always kept filled in case of emergency. The water-pipe for supplying the circulating-tanks for the gas-engines, which are fitted in the roof of the turret, also runs along the swing-span at rail-level. Flexible hose-connections for these pipes are provided at the junction of the swing-span and the fixed spans.

Signalling and lighting. — The viaduct being for a single line of rails, whilst the rest of the line is double, single-line junction-boxes are provided at either end of the bridge. This section is worked on the electric train tablet block-system.

In addition to the tablet block-system, the following provision is made for control of the single line from the bridge-turret, by which no train can be accepted by the adjacent signalman without the permission of the operator in the turret. In the turret, there is a bridge-controlling lever which must be in position before any of the lifting or turning operations can be performed. The movement of this lever unlocks the bridge, the position of the lever being electrically indicated in the signal-boxes at either end of the bridge. When the bridge-controlling levers in the signal-boxes at either end of the bridge are in their normal positions, the bridge is unlocked, and the single-line train tablet-circuit, the down-block on the south side, and the up-block on the north side are disconnected simultaneously. When the bridge is in position for a train and the bridge-controlling levers are over, the train tablet-circuit and the up and down block-circuits are connected up; on the withdrawal of a tablet, a bridge-controlling lever is electrically locked in position by the tablet. When once the turret-man has withdrawn the bearing-blocks, the bridge-controlling lever is electrically locked until the blocks are again home. In the case of a failure of the electrical or mechanical locking an Annett key is provided in both the north and the south boxes, the withdrawal of which from the lever-frame locks the home-signals. By placing this key in a special locking-box near the end of the swing-span, the two plungers — one worked from the box and the other from the turret — can be withdrawn, thus releasing the bridge and leaving it free to open. The levers in the turret are grouped, and the movements are electrically repeated, *viz.*, bridge locked, bridge unlocked, bridge lifted, bridge lowered, blocks on, blocks off.

An efficient arrangement for day and night signalling for the river-traffic, by means of balls and lamps, has been provided to meet the requirements of the Yarmouth Harbour Commissioners, and has been approved by the Board of Trade. For the purpose of steering vessels through the bridge, green lights have been fixed on the centre dolphin and white lights on the two adjacent dolphins.

Testing of the bridge. — The testing of the bridge took place on 8 July, 1903. A train of the heaviest engines was placed upon each span in succession. The deflection of the longer fixed spans was 0·68 inch, the calculated deflection being 0·62 inch. The deflection of the shorter fixed span was 0·375 inch, the calculated deflection being 0·39 inch. The deflection of the swing-span under live load was not taken; the calculated deflection was 0·02 inch. The swing-span was tested for dead-load deflections when swinging, after the completion of the erection, and at the same time the pressure required to remove this deflection was recorded by gauges. The deflection was $^1/_2$ inch, and the four pressures were about 30 tons each. The corresponding figures as calculated were 0·375 inch and 30·3 tons.

The whole work has been carried out in three contracts under Mr. Alexander Ross, M. Inst. C. E., as engineer-in-chief, and Mr. William Marriott, M. Inst. C. E., district engineer and locomotive superintendent to the Midland and Great Northern Railways Joint Committee, as executive engineer, to whom Mr. Graham Gribble, M. Inst. C. E., acted as chief assistant, and Mr. A. E. Glennie as resident engineer, Mr. W. E. Newman, superintending the mechanical portion of the work. The contractor for the substructure was Mr. Henry Lovatt, of Wolverhampton, and the contractors for the superstructure were Messrs. E. Finch & Co., of Chepstow. The hydraulic equipment was supplied and fixed by Messrs. Sir William G. Armstrong, Whitworth & Co., of Newcastle.

The paper is accompanied by nine drawings, from which the figures have been prepared; and by nine photographs, which may be seen in the library of the institution.

[625 .251]

TEST OF THE SAUVAGE AIR BRAKE,

By Geo. L. FOWLER.

Figs. 1 to 7, pp. 45 to 49.

(*The Railroad Gazette.*)

Ever since the introduction of the air brake into freight service, it has been recognized that a means should be found whereby the *pressure on the brakeshoes* should be proportioned to the weight on the wheels. The current method of adjusting the leverages, so that 70 per cent of the weight of the empty car is used in brakeshoe pressure, leaves only about 23 $^1/_3$ per cent of the weight of a loaded car of 60,000 lb. capacity available as brakeshoe pressures, and this meagre percentage is cut down still further, so that it is less than 20 per cent in the case of a car of 100,000 lb. capacity.

The Sauvage safety brake is intended to overcome this trouble and to substitute for the ordinary arrangement, one that permits the use of the full 70 per cent of the loaded weight of the car. It also provides a greatly increased braking power with a small addition to present equipment, and with no increase in the consumption of compressed air, or it makes it possible to attain the present brake power with a considerable saving in the consumption of air. The device was tried tentatively on the New York, Ontario & Western Railroad in the summer of 1904, and in the fall of the year, it was decided to so equip the milk cars of the road. This has been done, in part, as fast as the work could be carried on at the Middle town shops, and early in September, 1905, a series of tests were made to determine the relative efficiency of this brake in comparison with the standard Westinghouse equipment.

The arrangement as used and recommended by the Sauvage Safety Brake Co., of 42 Broadway, New York, consists of a second cylinder coupled to the brake levers in such a way that it comes into action only after the piston of the first cylinder has travelled a predetermined portion of its stroke, brought the shoes to a bearing against the wheels and applied the ordinary braking pressures.

The illustration shows this connection. No change is made in the triple valve auxiliary reservoir, or the brake cylinder connection, with the exception of the connection of the auxiliary cylinder. This is so arranged that its piston is not acted upon by the air, until that of the first cylinder has done all of the work of taking up the slack, and adjusting the brakeshoes to the wheels.

The air is admitted to the regular brake cylinder, A, in the usual manner from the auxiliary reservoir. When its piston has moved out to a point uncovering the opening to the pipe, C, air is admitted to the rear of the second cylinder, B. In the meantime, while the piston of A is travelling out it is carrying the swinging lever to which the piston rod of the cylinder, B, is attached, with it, and this in turn, pulls out an extension of the piston of B, as will be explained later. It will be seen, then, that as soon as air is admitted to the second cylinder, it transmits through the swinging lever a pull upon the cylinder lever at the point of attachment of the piston rod of A, twice as great as that of the latter if the cylinders are of the same size, on account of the multiplying effect of this lever. In this way, if the brake cylinder pressures were the same, the brakeshoe pressures would be three times as great as when the single Westinghouse cylinder were used, which is about the increase needed between an empty and loaded car of 60,000 lb. capacity.

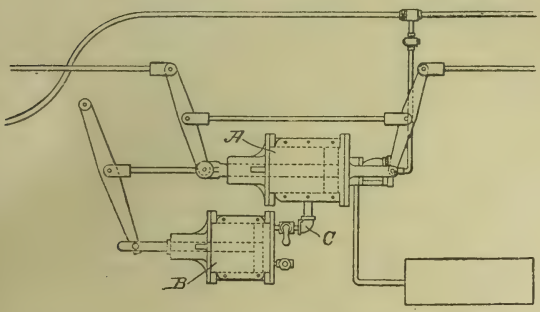


Fig. 1. — General arrangement Sauvage safety brake.

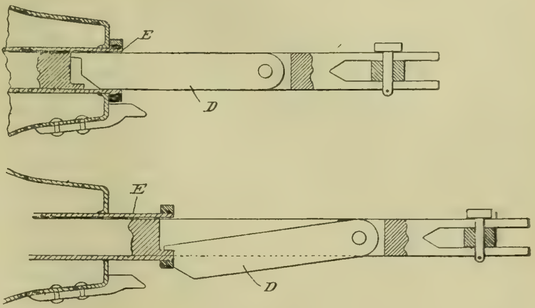


Fig. 2. — Detail of auxiliary cylinder piston rod and latch of Sauvage safety brake.

The mechanism by which the extension of the piston rod of the second cylinder is drawn out, is shown in the illustration. The main piston rod is hollow, and the extension telescopes into it. To the extension there is hinged the drop piece, or latch, D, which when lifted to the central position slides in the hollow rod. When it is drawn out beyond the edge of this hollow rod, it drops down and catches on the end of the same, as shown in the lower portion of the engraving. Then when air is admitted to the second cylinder, the rod catches on the drop piece and does its work through it.

When the brakes are released, the two pistons retract together, and as the end of the drop piece, D, approaches the cylinder head, it is raised by the inclined lug attached to the latter to its central position, and slides into place in the piston rod.

A cut-out cock in the pipe C, by which the second cylinder can be put out of use, completes the mechanism of the new device, and in it there is nothing of complication or anything that is apt to get out of order. When it is desired to use the single cylinder on empty car work, the cock in the pipe C is closed, and the extension to the piston rod of the second cylinder is merely drawn in and out. To use the cylinder, the cock is opened, thus practically duplicating the work of attention required by the ordinary retaining valve.

It has been found to be unnecessary to close the valve for empty cars in service, as will be shown in greater detail later on.

In order to provide for the semi-automatic adjustment of the cylinder and guard against the use of the second cylinder on an empty car where there might be a danger of flattening the wheels, various forms of automatic cut-out valves have been devised, one of the first forms of which is shown in section in the engravings, and its operation is as follows :

It is placed in the pipe C together with the cut-out cock, the latter to be used for emergencies only.

Within there are two valves, O and *n*, opening downward and held against their seats by springs. The stems of these valves project up into a cylindrical space in which a piston *q* is free to move up and down. Above this piston, there is a disc with a packed stem *r* that can be depressed by the double-acting lever *s*. This is so constructed that no matter which way the upper portion is moved, the central part will come down against the disk stem and push it and the piston down.

The device has been tested on a number of cars on the New York, Ontario & Western Railroad. The first trial was on a passenger train, where its work was so satisfactory that the equipment of all of the milk cars on the road was ordered, and this is nearly completed. These cars are of the ordinary type, are equipped with Fox trucks, and weigh empty about 38,850 lb.

It was desired to make a comparative test of the stopping and working qualities of this new brake with the ordinary Westinghouse equipment, in order to obtain the stopping efficiency, the amount of air used and the control of the train. That this might be done, trains were placed at disposal for the execution of the work. This was done in the regular service of the road, with no interruption and no variation except as noted later. The cars, when loaded, carried about 30,000 lb. of milk and 3,600 lb. of ice each.

The main tests were made with the leverage recommended for use with the Sauvage brake against the high-leverage in connection with the Westinghouse brake.

The work was done between Sidney and Middletown, a distance of 121·31 miles. The trains used for the greater portion of the work, with the cars loaded, were in regular milk service scheduled to leave Sidney at 1·35 p. m. and to arrive at Middletown at 7·30 p. m. On the return trip with empty cars, the work was done on the trains scheduled to leave Middletown at 7·35 p. m. and arrive at Sidney at 1·25 p. m.

In order to secure an autographic record of the brake events throughout the whole period of the run, an instrument especially designed for the work was placed in the eight-wheeled caboose car that was attached to the rear end of each train tested.

This instrument was fitted with a driving mechanism, by which a roll of brown manila paper 14 $^1/_2$ inches wide was driven over the table and rolled upon a reel at the end opposite to that from which it started. The driving was done by gearing worked from one of the axles, and the reduction of motion was such that the paper travelled 20·75 inches for each mile travelled by the car.

The registering apparatus consisted of six stylographic pens, each of which drew a continuous line from one end of the run to the other.

The indications of the several pens were as follows :

The pen at one end of the row, which made the line shown at the bottom of the record, was attached to the armature of a double magnet, so arranged that if the circuit through one magnet coil was closed, the armature would be drawn in one direction, whereas if that passing through the coil of the other magnet, it would be drawn in the opposite direction.

This pen was used to indicate the passing of mile-posts and stations. Two sets of circuit wires were led from the two magnets to the monitor of the caboose, and there provided with push buttons. According as the circuit was closed by one or the other of these buttons, the pen was moved up or down, causing a notch to appear in the line, and thus locating the mile-post or station, as the case might be. The pen was moved upward to indicate mile-post and downward to indicate station location.

The second pen was attached to an armature the magnet of which was in a circuit that was closed at intervals of ten seconds by a clock. As the paper travelled at a speed in direct proportion to that of the car, the speed of the latter can be determined at any moment of time or place by the distance separating the notches on the second line, as they are farther apart the higher the speed. A suitable scale makes it possible to measure this speed at once.

The third pen was attached to an armature the magnet of which was in a circuit closed by a wiper on the driving mechanism. These marks measure distances of about 570 feet, and were used as a check on the mile-post and for use in the determination of short distances.

The fourth pen was attached to the piston rod of a small cylinder, to the rear end of which the train pipe pressure was admitted. This piston was held normally at the rear end of the cylinder by a spring, which was compressed when the train pipe pressure was admitted. As this pressure was lowered by the application of the brakes, the spring pushed the piston back towards the end of the cylinder, carrying the pen with it and thus registering the reduction made for the application of the brakes.

The fifth pen was attached to the piston rod of a similar cylinder, to which the brake cylinder pressures were admitted. Normally, the piston was held by its spring against the back head of the cylinder, to be pushed out, compressing the spring when the brakes were applied, thus registering the brake pressures used and indicating on the record where the work was done.

The sixth pen was fixed and served merely to draw a base line.

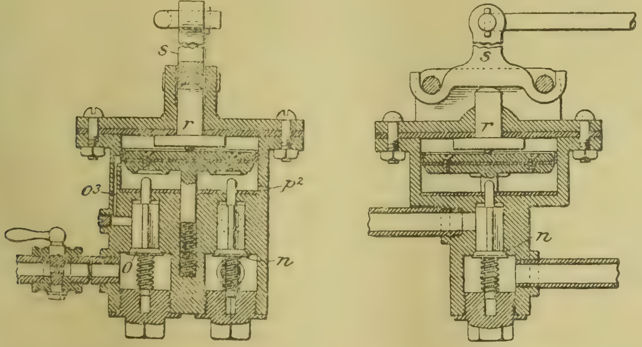


Fig. 3. — Sections of Sauvage automatic cut-out cock.

The whole of the record was thus autographic, with the exception of the indications for mile-posts and stations, which were made by an assistant in the monitor.

In this way a complete record, unaffected by the personal equation of the operator, was obtained showing the intensity, character and location of all the brake events, as well as the speed of the train with its accelerations and decelerations due to engine pull or brake applications.

In addition to this principal instrument, a pressure recording gage was placed in the caboose and connected with the train pipe.

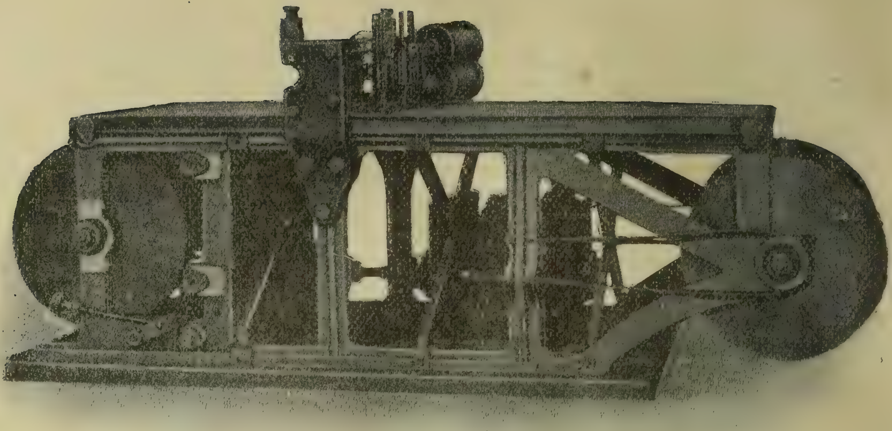
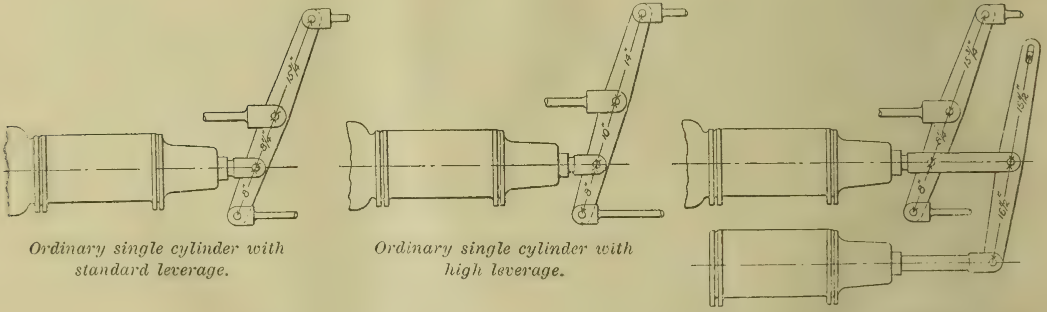


Fig. 4. — Autographic recording apparatus used in Sauvage brake tests.



Ordinary single cylinder with standard leverage.

Ordinary single cylinder with high leverage.

Sauvage cylinders with standard leveragc

Fig. 5. — Method of attaching and cylinder lever and proportions used in the Sauvage brake tests.

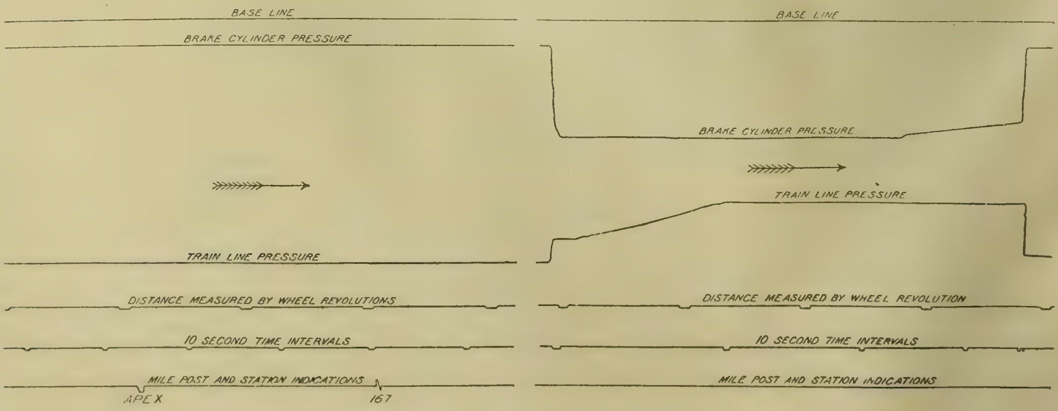


Fig. 6. — Specimen of autographic record of brake events in Sauvage brake tests.

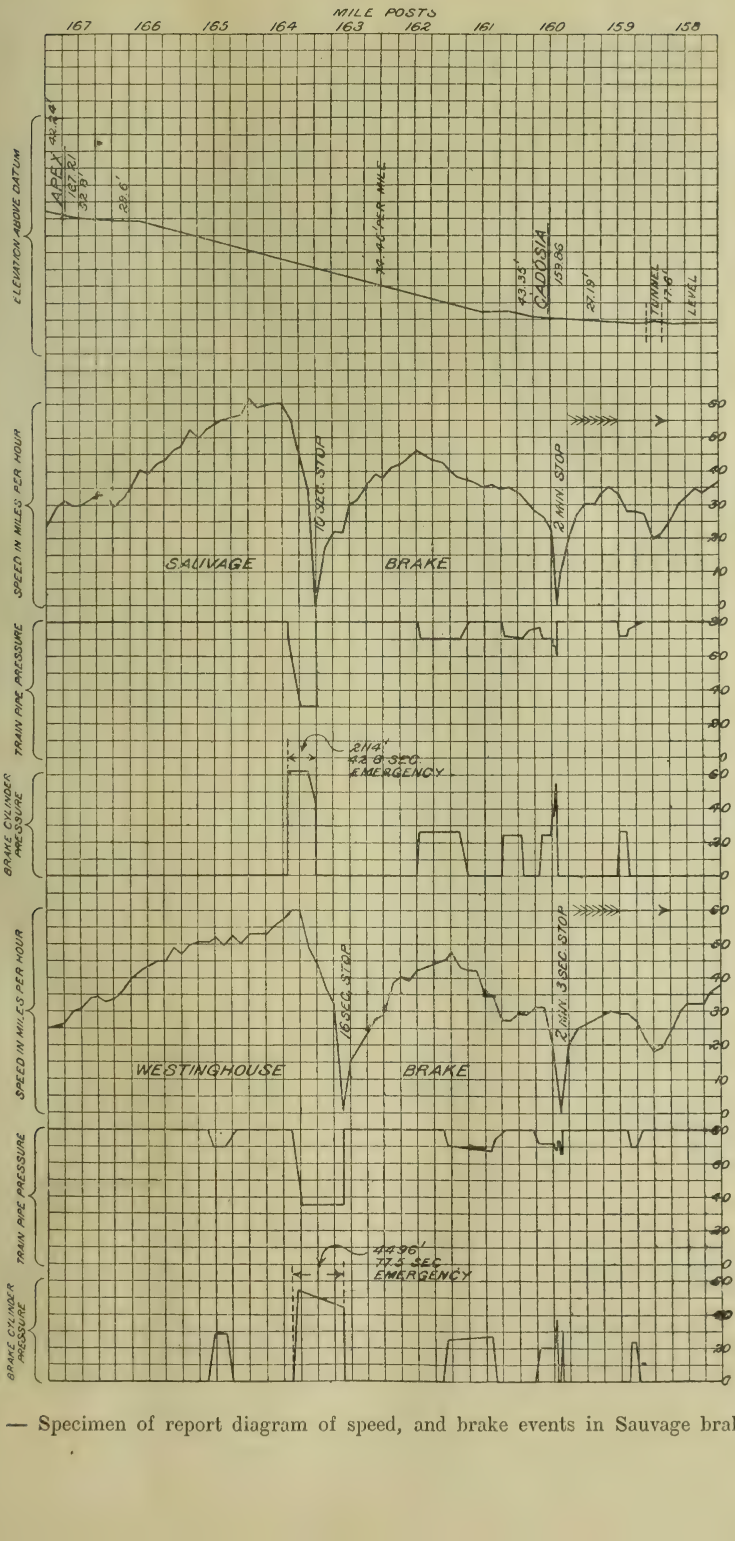


Fig. 7. — Specimen of report diagram of speed, and brake events in Sauvage brake tests.

On the engine, there was a stroke counter attached to the air pump.

Work was commenced on a run from Sidney to Middletown on August 29, 1905, and finished on a run from Middletown to Sidney on September 12, 1905.

In all, ten runs were made. Of these, three were with loaded cars and the Sauvage brake from Sidney to Middletown; three with loaded cars and the ordinary air brake, using the high leverage, over the same run; one the same as the above, except that the standard leverage was used; one from Middletown to Sidney with the Sauvage brake and empty cars; one the same as the last except that the Sauvage brake was coupled to the high leverage used with the ordinary brake, and one with the latter and high leverage.

The trains were hauled by the same engine and engineer with one exception, and were as near the same composition and weight as the exigencies of service would admit. There were some variations in the brake equipment, as will be noted. The following is a detail of the composition of the several trains that were used between Sidney and Summitville, between which points all of the special stops were made :

DATE.	Number of cars.	Brake.	Weight of train, in lb.	Direction of movement.	*Remarks.*
August 29. . . .	11	Sauvage.	761,290	South.	One car was not fitted with Sauvage brake. Cloudy, wet and dry rail.
— 31. . . .	10	Ordinary.	774,838	—	Clear, dry rail.
September 2 . . .	7	Sauvage.	578,852	—	One car (6029) cut out. Rainy, wet rail.
— 6 . . .	9	Ordinary.	669,813	—	Clear, dry rail.
— 7 . . .	11	—	540,600	North.	— —
— 8 . . .	9	Sauvage.	687,239	South.	— —
— 9 . . .	13	—	629,600	North.	— —
— 10 . . .	9	Ordinary.	675,362	South.	One car (6033) standard leverage. Clear, dry rail.
— 11 . . .	12	Sauvage.	582,300	North.	Foggy. Damp rail to Livingston Manor.
— 12 . . .	8	Ordinary.	642,443	South.	Cloudy, dry rail.

In this list, the caboose is not counted in the number of cars, nor is the engine included in the weight of the train. This is placed at the uniform figure of 275,500 lb.

In doing this work, arrangements were made for a series of special stops in each direction, so that comparisons could be made between the action of the two brakes at the same point in the track and at approximately the same speeds, independent of the regular service work.

The special stops were made as follows :

SOUTHBOUND (LOADED TRAIN).

Emergency stops from full speed.

At mile-post 163, on descending grade of 74·45 feet per mile into Cadosia.
— 150 (East branch), level.
— 113, on descending grade of 59·66 feet per mile into Luzon.
— 102 (Mountaindale), descending grade of 64·26 feet per mile.

Service stops from full speed.

At mile-post 154 (Fish's Eddy), ascending grade 50·21 feet per mile.

NORTHBOUND (EMPTY TRAINS).

Emergency stops from full speed.

At mile-post 92, on descending grade of 52·8 feet per mile into Summitville.
— 150 (East branch), level.
— 189 (Franklin), descending grade of 66 feet per mile.

Service stops from full speed.

At mile-post 135 (Rockland), level.
— 171 (Rockrift), descending grade of 68·32 feet per mile.

A higher leverage than that previously employed was used, and is shown in the engraving, in which the arms of the cylinder lever are 8 1/4 and 15 3/4 inches long, and which is marked "standard" leverage. The high leverage is shown on the engraving, in which the lengths of the two arms are 10 and 14 inches, respectively; a change that increased the pull on the rod leading to the trucks from 0·523 to 0·714 lb. for each pound of pressure in the brake cylinder; an increase of 36·52 per cent.

In the case of the Sauvage brake, the arms of the main cylinder lever are of the same length as in the standard leverage arrangement of the ordinary brake. In addition to this, the Sauvage cylinder is attached to a lever that doubles its pull on the cylinder lever; so that when the second cylinder is at work, the effect is the same as though three 8-inch cylinders were connected to and acting upon the end of the main cylinder lever.

A fourth engraving shows the arrangement of the foundation brake rigging under the milk cars with which these tests were made.

Following these leverages out from the cylinder to the brake-beam, it will be seen that the pressure upon the beam for each pound of pressure in the brake cylinder will be for :

Ordinary brake (standard leverage)	2·22 lb.
— — (high leverage)	3·03 lb.
Sauvage —	6·67 lb.

For an equalization of the brake cylinder pressures at 55 lb., the brake-beam loads were as follows :

Ordinary brake (standard leverage)	6,137 lb.
— — (high leverage)	8,376 lb.
Sauvage —	18,328 lb.

At 60 lb., this becomes for the ordinary brake with :

Standard leverage	6,695 lb.
High —	9,137 lb.

Il will be shown later that 55 lb. was the maximum pressure obtained in the Sauvage cylinders. The average weight of the loaded car was 73,610 lb.

These equalized pressures under emergency application, therefore, show the following percentage of the weight of the car in the brakeshoe pressure.

	Cars.	
	Empty.	Loaded.
For 55-lb. brake cylinder pressure :		
Ordinary brake (standard leverage)	63·18 per cent.	32·80 per cent.
— — (high leverage)	86·23 —	45.51 —
Sauvage —	188·49 —	99·59 —
For 65-lb. brake cyllnder pressure :		
Ordinary brake (standard leverage)	74·66 per cent.	39·46 per cent.
— — (high leverage)	101·91 —	53·79 —

In the case of these tests, a train pipe pressure of 80 lb. was used, which equalized in the cylinder of the caboose at 65 lb.

It was the intention to use the same engine worked by the same crew during all of these trips; but, owing to the floods and the consequent disturbance of the service about the first of September, another engine of the same kind and weight, but with a different braking power, was used on the southbound run September 6, with a loaded, ordinary high-leverage brake. This extra braking power, amounting to about 42 per cent, tended to lower the length of the stops on that day.

The caboose was not equipped with the Sauvage brake. The result is that the pressure registered by the cylinder of that car is somewhat higher than in the Sauvage cylinders on the balance of the train.

In order to determine just what allowance should be made for this, a standing test was made with the result that the Sauvage brake cylinders equalized at a lower pressure than the single cylinder of the Westinghouse system. The difference in their equalizing pressure, amounts to about 10 lb.; that is to say, with a pressure of 65 lb. in the brake cylinder of the caboose, the cylinders of the train would have a pressure of 55 lb.

In addition it has been found, by means of a dynamometer placed in the pull-rod, that the stress actually transmitted to the brakeshoe is considerably less than that called for by theoretical considerations. This loss of power is due to the frictional resistance of the cylinder packing, the friction of the levers on their pins and the binding of the connections. In all, it amounts to about 22 per cent.

It follows, then, that the actual brakeshoe retarding force is much less than that called for by the theoretical calculations. Consequently, instead of having 188·49 per cent of the weight of empty and loaded cars in brakeshoe pressure, it becomes 147·02 and 77·68 per cent respectively.

The travel of the brake cylinder pistons was kept in careful adjustment throughout the whole course of these tests at from 5 to 6 inches with the ordinary brake, and from 7 to 7·5 inches with the Sauvage brake.

The accompanying engravings show samples of the work transcribed from the original. One shows the time, distance and location marks when running; a second is a copy of the record of the emergency stop made on September 8 near mile-post 164. A third is a short section from the details of the report showing the grade of the road, the location of the mile-posts, the points of brake application, the amount of train pipe reduction and the brake cylinder pressures. The upper set of lines and figures refer to the work of the Sauvage brake with a loaded train on September 8, and the lower lines to the run with a similar test and the ordinary brake with the standard leverage August 31.

The records of the special emergency stops were as follows :

DATE.	Brake.	Location at milepost.	Grade, in feet per mile.	Speed per hour, in miles.	Time required to stop, in seconds.	Distance run after brake application, in feet.
August 29	Sauvage.	151	+ 1·32	42	17·50	713
— 29	—	113	—59·66	37	22·50	708
September 2.	—	163	—74·45	60	50·75	2,544
— 2.	—	150	Level.	41	31·00	1,073
— 2.	—	113	—59·66	46	29·22	1,228
— 2.	—	102	—64·26	44	33·30	1,123
— 8.	—	163	—74·45	60	42·80	2,114
— 8.	—	150	Level.	44	20·80	679
— 8.	—	113	—59·66	44	24·10	898
— 8.	—	102	—64·26	45·5	28·50	1,050
— 9.	—	189	—66·00	48	20·00	858
— 9.	—	150	Level.	48	19·40	687
— 9.	—	92	—52·80	52·5	31·10	437
— 11.	—	150	Level.	43	22·40	787
— 11.	—	92	—52·80	51	30·20	1,113
August 31 (1).	Ordinary.	163	—74·45	60	77·50	4,496
— 31 (1).	—	150	Level.	42	...	1,202
— 31 (1).	—	113	—59·66	38	31·20	1,088
— 31 (1).	—	102	—64·26	45·5	51·90	2,099
September 6 (2).	—	164	—74·45	60·5	45·70	2,293
— 6 (2).	—	113	—59·66	59·5	46·50	1,734
— 6 (2).	—	102	—64·26	47	40·00	1,622
— 7 (2).	—	189	—66·00	52	31·20	1,218
— 7 (2).	—	150	Level.	51	28·50	1,117
— 7 (2).	—	92	—52·80	55	43·90	1,733
— 10 (2).	—	185	—74·97	51	42·74	1,920
— 10 (2).	—	163	—74·45	62	62·80	3,176
— 10 (2).	—	150	Level.	39	18·16	729
— 10 (2).	—	113	—59·66	50·5	51·20	1,700
— 10 (2).	—	102	—64·26	40	38·60	1,230
— 12 (2).	—	185	—74·97	57	50·60	2,306
— 12 (2).	—	161	Level.	57	62·20	2,799
— 12 (2).	—	150	Level.	42	37·00	1,033
— 12 (2).	—	113	—59·66	49·5	39·50	1,448
— 12 (2).	—	102	—64·26	46·5	41·10	1,571

(1) Brakes worked with Standard leverage. — (2) Brakes worked with High leverage.

In these, the ordinary brake was used with the standard leverage on August 31, and with the high leverages on September 6, 7, 10 and 12. The Sauvage brake was worked with the standard leverages at all times except on September 11, when it was attached to the high leverages.

In the comparison of these records, a certain amount of grouping is required.

The runs with the Sauvage brake on August 29, September 2 and September 8, may be compared with the high-leverage tests of the ordinary brake on september 6, 10 and 12.

The same rune of the Sauvage brake, may be compared with the standard-leverage test of the ordinary brake of August 31.

The run with the Sauvage brake of September 9, may be compared with that of the ordinary high-leverage run of September 7.

The run with the Sauvage brake, coupled to the high leverages, of September 11, may be compared with the run of the ordinary brake of September 7.

Taking up these tests in detail, it is seen that, grouping the three runs of August 29, September 2 and 8, there were nine emergency stops made from an average speed of 47·68 miles per hour, and that the average length of stop was 1,364·6 feet. The average record for the tests of September 6, 10 and 12 is for speed 50·88 miles per hour and for distance 1,819·3 feet.

This shows a loss of 6·27 per cent in speed, and a reduction of 25 per cent in distance for the Sauvage brake. If, however, we consider the length of the stop to represent the actual amount of work done, and that this varies with the square of the velocity, it will be found that there is an increase of efficiency of 18·3 per cent.

It must be borne in mind, however, that in this comparison, the ordinary brake was working with a leverage that results showed, as will be indicated later, is impractical for regular service work.

If now we compare the runs of August 29 and September 2 and 8 with those of August 31, we have, as before, for the former an average speed of 47·68 miles per hour, with an average distance of 1,364·6 feet run after the application of the brakes, while for the run of August 31 the average speed was 46·37 miles per hour and the distance 2,221 feet. This shows an increase of speed for the Sauvage brake of 2·82 per cent, and a decreased average distance of 38·56 per cent. Applying the principle of squares of velocities to this series, we find that the increased efficiency of the Sauvage brake is 43·89 per cent.

This is a fairer comparison on the basis of service work than the preceding one, in that both brakes were operated with the regular leverages that are used in service.

On September 8 and August 31, the conditions of operation were most nearly identical. September 8 was the only trial of the Sauvage brake in which all cars were equipped with it; the weather conditions were the same, both brakes were working on the standard leverage, and the weights of the two trains, including engine and tender, were 961,600 lb. for the Sauvage and 1,051,000 lb. for the ordinary.

Taking up the stops in detail, they were as follows :

	Sauvage.		Ordinary.	
	Speed, in miles per hour.	Distance, in feet.	Speed, in miles per hour.	Distance. in feet.
Milepost 163.	60	2,114	60	4,496
— 150.	44	679	42	1,202
— 113.	44	898	38	1,088
— 102.	48	1,050	45·5	2,099

In this, there was a saving of distance on the part of the Sauvage brake in actual distance at

Milepost 163. . .	52·98 per cent.	Milepost 113. . .	38·45 per cent.
— 150. . .	43·51 —	— 102. . .	50·00 —

If we equate on the basis on the squares of the velocities, the saving of distance on the part of the Sauvage brake was at

Milepost 163. . .	52·98 per cent.	Milepost 113. . .	17·48 per cent.
— 150. . .	51·09 —	— 102. . .	55·06 —

This is an average of 49·39 per cent, with a minimum of 38·45 per cent, from which it seems safe to conclude that, at the same speeds, the Sauvage brake will stop a loaded train in from 40 to 50 per cent shorter distance than the ordinary. In other words, it will require from 1·66 to 2 times as great a distance in which to stop a train with the ordinary than it will with the Sauvage brake.

The shorter the train, the greater was the distance run. This is quite in accord with the expected in that, with a heavier train fully braked, the unbraked weight of the locomotive forms a smaller percentage of the whole in a long than in a short train. In other words, there is a greater amount of resistance in the train to effect the engine retardation.

The air consumption in these tests, was about the same in the case of the two trains. There was a certain varying amount of leakage from the train pipe at all times, and this was a burden that tended to increase the percentage of the brake using the smaller quantity and decrease the proportional difference between the two.

The total number of brake applications in the whole series, was 154 for the Sauvage and 172 for the ordinary, or an average of 39·7 for the Sauvage and 38 for the ordinary on the southbound runs, and 35 for the Sauvage and 32 for the ordinary on the northbound.

In order to ascertain approximately the air consumption on the two types of brakes when the special and emergency stops were eliminated and nothing but the working service conditions obtained, two runs were made between Norwich and Middletown, 146·95 miles.

The elapsed times between terminals were 6 hours 14 minutes 15 seconds for the ordinary brake, and 6 hours 53 minutes 30 seconds for the Sauvage train. Of this, 5 hours 13 minutes 15 seconds and 5 hours 40 minutes 51 seconds were occupied in running, respectively. The pump stroke counter registered 18,701 strokes for the ordinary brake and 10,558 for the Sauvage train. There were 54 distinct brake applications with the former and 37 with the latter. Taking the averages of the time and amount of train pipe reduction for the runs, they were a reduction of 12·25 lb. throughout a period of 37·64 minutes for the ordinary, and a reduction of 8·73 lb. for 24·93 minutes for the Sauvage brake. If these are compared on the basis of the products of these two sets of figures, it will be found that the train pipe reductions were but 47·10 per cent of those used on the ordinary brake train.

The air consumption, with allowances for leakage, amounted to 11,969 strokes of the pump with the ordinary brake and 5,608 strokes with the Sauvage brake, making the latter 46·85 per cent of the former.

If it is assumed that the cylinder capacities of the engine, tender and passenger car brakes, are equivalent to those of five milk cars the relative capacities of the two trains would be as 15 to 14. Dividing the strokes of the pump required for brake applications by these figures and comparing, it will be found that the Sauvage brake required only 50·25 per cent the amount of air per car in order to do the braking that was required by the ordinary brake.

It is, of course, unsafe to make broad generalizations from single tests, especially where there is a chance for a variation in the handling of the brake and the exigencies of the run; but it does seem fair to state that a loaded train can be handled on a much lower air consumption with the Sauvage than with the air brake as ordinarily applied. Whether this saving will range from 35 to 50 per cent, as these particular runs would seem to indicate, remains to be proved by future use and investigations.

One criticism may, however, be forestalled, and that is regarding the fact that the number of applications were fewer and the periods shorter. Both of these were due to the superior action of the Sauvage brake. Fewer applications were required in order to keep the train under control, because a higher speed was permissible on the grades, while the greater efficiency of the brake, when applied, reduced the period during which a brakeshoe pressure on the wheels was required.

There is one final point to which attention should be called, and that is the effect of the two brakes on the wheels. In this, the effect of the ordinary brake with the standard leverage may be disregarded. When the cars were worked with the high leverage, it was feared that there might be trouble on account of the sliding of the wheels. The engineer was, therefore, instructed to use and did use sand on all of the special stops with the ordinary brake and high-leverage brakes except on those of September 6, and on this day the most serious sliding took place on a clean, dry rail; whereas no sand at all was used on any of the stops with the Sauvage brakes. It is, therefore, evident that the ratio of effectiveness of the Sauvage brake in comparison with the ordinary, would have been much greater on all of the comparisons with the exception of that of August 31, had the conditions of application of the brakeshoes to the wheels been the same.

Even as it was, there was a serious amount of flattening according to the railroad reports as the result of these brake applications. In all, twenty-eight pairs of wheels were reported to have flattened with the high-leverage ordinary brake, and but four pair when the Sauvage brake and the high-leverage connections on the test of September 11, and none under current conditions. Since that time, no wheels have been flattened in the regular service using the Sauvage brake.

There has been no opportunity to investigate as to the exact reason for this, and a cause can, therefore, merely be suggested.

In the case of an ordinary brake in an emergency application, the whole of the brakeshoe pressure is put upon the wheel in the form of a blow. With the Sauvage brake, on the other hand, the regular cylinder takes up all of the slack, and puts on a pressure that causes the shoes to adjust themselves to the wheel. Then the second cylinder puts on the extra pressure, which thus takes on the form of static load instead of a blow, with the result that the effect on the wheels is not sufficient to bind and skid them.

The conclusions to be drawn from a consideration of this work is that the Sauvage brake is especially valuable in the case of loaded cars, and the situation may be summed up in the statement, that the advantages possessed for the Sauvage brake are not purchased at the expense of any modification in the present equipment that will require a change in the method of operation or the parts in use. The same triple valves, brake cylinders, levers and connections can be used as in the standard equipment. If these are already in position on the car, they need not be moved, for the new cylinder can readily be put in position beside or ahead of them, as in the case of the milk cars that have been tested.

The advantages offered by the device are that a brakeshoe pressure proportional to the weight on the wheels can be obtained, and this on about the same consumption of air that obtains for the ordinary brake working on empty car-wheel loads, and that for ordinary handling the air consumption is materially less. In short, it adds efficiency to the present brake without any additional complication and without any change in the standards of construction or operation o that to which railroad employees have been trained.

[621 .133.2]

FLEXIBLE STAY BOLTS.

(Abstract from a report presented to the Master Mechanics' Association.)

Figs. 1 to 3, p. 59.

(*American Engineer and Railroad Journal.*)

Committee : R. N. Durborow, chairman ; F. M. Whyte, C. E. Fuller, O. H. Reynolds.

The original flexible stay bolt, as far as can be determined from research by your committee, appeared about 1878, and was the invention of Herr Wehrenfennig, the chief engineer of material and traction of the North Eastern Railway of Austria, who also, it is claimed, was the first to draw attention to the need of a flexible connection between the two sheets of the boiler. This bolt in general design is similar to practically all that have followed, having a bolt proper with an enlarged head for applying and provided with a seat bearing against another seat provided for in a sleeve screwing into the outer sheet. The fire-box end was either fastened by riveting over or by screwing into a cap, but the main difference between this design and later ones is in the form of the seat which, in the Wehrenfennig, was flat, while all others have employed the ball and socket form.

No record of the service given by these bolts can be found, but about four years later, an improved form of this bolt was devised and put in service by Mr. W. Leech, foreman boiler maker of the Rajputana-Malwa Railway of India, who, in describing his bolt, stated that a large number were put in service in engines running in bad water districts, and that the bolts gave unqualified success, lessening stay-bolt renewals and prolonging the life of the boiler sheets.

Both the Wehrenfennig and Leech bolts were applied by first tapping the inner and outer sheets so that both holes were in alignment, next applying the sleeves, and lastly the bolt itself, by means of the square head extending from the head of the bolt, against which a sledge or "dolly" was held while the fire-box end of the bolt was being riveted over, the head remaining as an integral part of the bolt in the Wehrenfennig design, but is removed from the other form after it has served its usefulness in applying the bolt.

Your committee has no data as to how great an extent these early form of flexible stay bolts were used, but it is known that Leech never profited by his invention, from which it would appear that this was one of the useful inventions the merit of which was not fully recognized during the life of the patent. This brings the subject to practically the present day, and to determine the experience of members of the Association with bolts of this general form, your committee issued a letter of inquiry to which fifty eight replies were received. This may be considered as a satisfactory result, even though this does not represent a large percentage of the members of the Association as being interested in the subject. Thirty-two of the fifty eight replies received were from roads not using flexible stay bolts, but in the twenty-six answers from roads using them, a number of the most prominent roads were included.

Five hundred and twenty-one thousand, four hundred and thirty-five (521,435) flexible stay bolts, of seven different varieties, distributed in 3,012 boilers, have been put in service among the twenty-six roads using such bolts. Of these seven forms, those shown in figures 1 and 2 (figures 4 and 5 of the report) have been the most largely used. The design shown by figure 1, which is the earlier one, developed several serious defects traceable to the screw slot by which the bolts are screwed into the sheet. These failures were usually from the bottom of the screw slot through or into the neck, and in some cases in the neck itself. In the former, the head doubled on itself, closing the screw slot, giving very insufficient bearing on the spherical surface. Stopping the slot short of the edge to prevent this buckling did not prove to be a satisfactory solution; hence this form, shown in figure 1, has been largely superseded by that shown in figure 2, though the service with it cannot be said to have extended over a sufficient period to justify a decision as to its merits. The bolt employs the ball and socket head, but does not use the conical walls for the sleeve for breaking up scale deposited, and aside from the fault indicated previously, figure 1, has given satisfactory service, some roads replying that they have experienced no failures, but all roads that have adopted it as standard report otherwise, showing the advantage of wide experience.

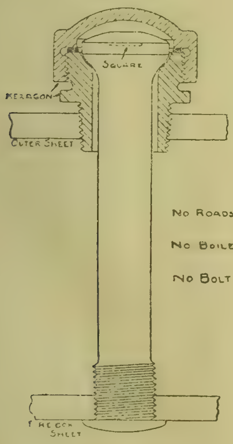


Fig. 2.

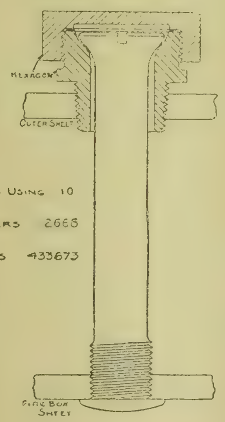


Fig. 1.

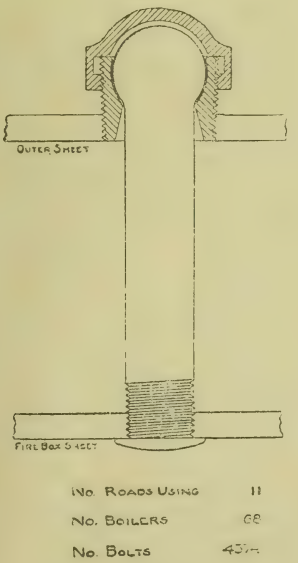


Fig. 3.

In point of favour, indicated by the number in use, figure 6 (not reproduced), follows the preceding forms, and, regarding the design, appears to be the most satisfactory, as only one road reports a failure, this failure being caused by faulty manufacture in punching the hole for th wrench too deeply. The ordinary ball and socket joint, having a bearing between the bolt and the sleeve, is used, the walls of the bore of the sleeve being conical and very short, and your committee believes that this latter feature is an improvement on the designs shown by figures 1 and 2, inasmuch as the space for the lodgment of scale is lessened.

Figure 3 (fig. 7 of the report) shows the latest design, and though of comparatively recent date has been received with great favour, indicating the rapidity with which a new bolt of promising design is given a practical trial in the effort to cure the stay bolt trouble. Its actual service, however, has been of such short duration that nothing can be said in its favour or otherwise. The principles of this design were used in an older form and include the spherical headed bolt and recess with conical walls in the sleeve, but better designed for manufacture and for application.

It has been demonstrated that in certain locations, the rigid stay bolt will not give reliable service in the large boilers carrying heavy steam pressure, and though very frequent examination will detect such failures before they become too numerous, nevertheless there is every indication that at certain locations some form of bolt that will allow of distortion without rupture is a necessity.

For solid bolts, some advocate a special grade of material, this being either a higher grade iron made up in the usual way, or iron made up in some special way. Your committee believes that, while good material is by all means desirable, it is firmly convinced that this alone will not overcome the troubles that have been experienced.

Besides changing the material, various modifications in the form have been tried and adopted, the general idea being to so shape the bolt that the vibration strains will not all locate themselves at one point, namely, the inside of the outer sheet. One of these special forms employs a bolt which is materially enlarged at the outer sheet, diminishing in diameter until the fire sheet is reached, the governing idea being that, by so shaping the bolt, the deflection will be distributed over its entire length. Experience shows that this result largely follows and that final fracture, when it occurs, may be at some distance from the sheet, but the disadvantage of tapping holes of different sizes in the two sheets, to say nothing of the greater expense of forming such bolt, renders its adoption very doubtful. The custom of reducing the diameter of the bolt between the two sheets, your committee believes to be a good one, provided the reduction is not made by an abrupt shoulder. Vibrating tests on the testing machine indicate that this reduction very greatly increases the capacity of the bolt to resist distortion, but it is the opinion of your committee that the reduction should not be carried too far, as it has been found in practice that with the size of bolts customarily used, a body $^3/_{16}$ inch less in diameter than that of the ends will give better results than a greater or lesser amount of reduction. Other forms of solid bolts have been used in fittings designed to practically increase the length of the bolt. Various modifications have also been made with the idea of giving the rigid bolt greater flexibility. One of these is a bolt which is flattened locally in planes at right angles to one another, but the results obtained were not satisfactory.

Other modifications, such as the milling of longitudinal saw-cuts in the body of the bolt, and of manufacturing the bolts in hollow form, have also been tried, the latter claiming to possess the additional advantage of better combustion and absolute indication of failure. Your committee is not prepared to admit that either of these claims have been proved.

All of these schemes have given more or less satisfaction, but none have fulfilled requirements to an extent that would warrant universal use.

Regarding the opinions of the users of flexible bolts as to the value resulting from a change from the rigid to the flexible form, the verdict is greatly in favour of the change, 50 per cent of the replies received being in the affirmative and including the largest users, the remainder, except one, answering in a manner that could not be interpreted as either for or against their value.

Concerning the location of flexible bolts, there appear to be four places applicable to all boilers that have proved to be a source of trouble to rigid bolts, and where the application of flexible bolts has stopped entirely, or to a great extent, the failures of the older form, these places being the two upper corners of the throat and side sheets. Beyond this, the application is increased as the individual judgment indicates.

Naturally the results obtained from flexible bolts vary to an extent, depending upon the conditions, these conditions including such items as design of the bolt, application of the bolt, design of the boiler, and incrustation, these four factors being the most important affecting its life. In the bolt itself it is admitted that, strictly speaking, it is not a flexible bolt, for though it is made in two parts it still has to withstand bending strains, due to the manner of expansion in the sheets, the bending taking place at some point near the inner sheet. This action be overcome by employing a flat bearing surface at right angles to the head of the bolt instead of the ball and socket joint as commonly used. As better contact is maintained between the head and sleeve in actual service with the ordinary form, and further, as trouble has seldom been known to result from the bending strains due to the expansion of the sheets, which would be indicated by bolts breaking at some point near the inner sheet, or by leaking at the fire-box end (a trouble that is seldom, if ever, encountered), it is evident that this is a trifling fault, but one that should be borne in mind while considering the designing of new bolts. The finding of the point of failure of stay bolts at the outer sheet, and that the failure seldom, if ever, takes place at the inner sheet, is possibly due to the high temperature of the fire-box making the inner sheets more elastic. This allows them to bend to an extent, relieving the stay bolt to some degree of the strains imposed upon it at this point. It should also be remembered that in most designs the outer sheet is materially thicker than the inner or fire-box sheet.

A simple means of positively detecting cracked and broken bolts is an improvement needed by all flexible bolts that are in service at the present time. The removal of the cap, which will allow a proper examination of the bolt, is the only absolute means possible with flexible bolts of present design. On account of corrosion, it is not an easy method and often results in destrucion of the cap. The inspection of flexible bolts located in side sheets and back head can only be made by the removal of lagging. The designing of the flexible bolt, so that the tell-tale hole may be employed, by filling the space between the head of the bolt and the cap with a packing material, may or may not be a good feature for determining cracked and broken bolts. As the use of the tell-tale hole is a disputed practice, its action not being accepted as positive, and as it adds to the expense of application and maintenance, it is not to be recommended for this purpose.

The first consideration in the application of bolts, should be the securing of proper alignment of the holes in the inner and outer sheets, in order that the clearance between the bolt shank and the sleeve may not be decreased, leaving a larger amount on one side than on the other, and so reducing its value as a flexible bolt when expansion of the sheets takes place, as this will give the possibility of an added strain upon the bolt due to the bolt shank acting as a lever arm with the sleeve as a fulcrum. Also if the bolt and sleeve do not contain the same perpendicular for a center line, an indirect strain comes upon both members. These two conditions, which may occur in conjunction, giving complex strains to the bolt and sleeve, will undoubtedly affect the life of the bolt to some extent; but even if each occurs separately, the already severe service of this member of the boiler is unnecessarily added to, reducing its life to an extent commensurable with the increased demands. The cure for these faults is simple, only needing care in the final reaming and tapping of each pair of holes. Unfortunately, however, none of the methods employed in the application of flexible stay bolts were described by the members in their reply to the circular.

There also exists the possibility that in applying the bolts, different ones may be given varying initial strains, those receiving the greatest naturally suffering the hardest service, and it is easily seen that with a great enough difference in initial strain between one bolt and those surrounding it, rupture may be an easy matter.

The effect of the design of the boiler upon the life of the bolt can be seen from the accompanying diagrams, figures 29 to 45 (not reproduced) inclusive, which give the records of broken stay bolts. These figures show the failure of both flexible and rigid bolts, and the tabulations on these sheets show the method of indicating such failure and, also, give other information from which it can be said that each class of boiler has its own local weakness at which failure occurs most frequently; but in general it may be said that the point at which there is a bend in the sheet is one where failure may be expected. In some of the later designs, particularly those of wide fire-boxes, the greatest number of failures occur at the first few rows above the mud ring.

Incrustation has been the principal difficulty that flexible bolts have had to contend with, and this trouble has been the cause assigned for most failures, there being but little doubt that this is true, for the deposit of solid matter around the bolt and its parts will defeat the purpose of the flexible bolt, making it of little more value than the rigid; and, though the fault may be a local one, affecting only such engines as run in districts supplied with scale-forming water, any design of flexible bolt which will admit of this taking place, is in general a weak design.

It may be said that all bolts of to-day possess this fault, though some, in a manner, have obviated the difficulty. A fault common to all lies in the sleeve, which should not be made too large on account of weakening the outer sheet, nor should the bolt be decreased for reasons of strength, the result of either being an increase of clearance around the bolt. The proper procedure is the omission of that portion of the sleeve below the seat of the bolt, thus preventing the possibility of the scale being deposited between the bolt and sleeve, preventing free movement of the bolt with the movement of the sheets. Some designs have made use of a conical wall in the sleeve to aid in keeping the scale from collecting, but it has been found from experience that this feature, aided by the movement of the sheets and continual jarring of the engine, does not serve its purpose under all conditions. Such scale that is deposited is formed grain by grain, and may result in a hard, homogeneous mass which will take a heavy blow to break up, yet the only action that takes place between the bolt and sleeve is of a grinding nature, which at the most will keep but a small space around the bolt clear, and any movement beyond the average demanded of the bolt will not be met.

In such varieties of bolts that use the flat head, incrustation will surely produce a solid bolt if conditions are favourable, the time depending on the amount of clearance between the bolt head and cap, for water and steam get past the seat of the bolt and sleeve, depositing such salts as may be contained. With the spherical-headed bolts, this cause of rigidity may be overcome or lessened, for, theoretically, all the clearance required by this form is anything less than actual contract and, practically, enough to provide for irregularities due to manufacture. It is safe to assume that this amount of clearance will always be present, due to vibration and movement of the bolts.

There has been a small amount of trouble that neither of the above forms provide for, namely, if scale is deposited above the head of the bolt, no provision is made for taking care of expansion of the bolt and approaching of the sheets, which has been known to result, with sleeves using brass caps, in the forcing out of the center of the cap. It is evident that the amount of trouble resulting from incrustation depends entirely upon the amount of solid matter contained in the water and whether it deposits as a hard or soft scale.

The fact that there is a movement of the fire-box and outer sheets has always been recognized, but what this movement amounts to and the direction it takes appears to have been known only in a vague and indefinite way, an investigation of a thorough character having apparently, from a careful research by your committee, never been conducted. Considering the different sheets that form the fire-box of the boiler as plane surfaces, expansion of these sheets takes place in two different planes, one in a plane containing the sheets that may be under consideration, and the second is a plane perpendicular to these sheets, it being a separation or approaching of the inner and outer sheets of the boiler. In an investigation, the individual expansion of each sheet is of no definite value, for if both the inner and outer sheets move the same amount in the same direction, no change of position of the stay bolt would take place, but if the expansion of each sheet occurred in opposite directions the movement of the bolt would be greatest. From this it is seen that all that concerns the bolt is the relative movement of the inner sheet with respect to the outer.

The expansion of the two sheets in their own plane, which, for convenience, may be called horizontal, is due to the changes of temperature, but the expansion in the other direction, which may be called the vertical expansion, is due to a combination of forces, among which are the expansion of the stay bolts, the buckling tendency due to the expansion of the sheets in a horizontal plane being confined to a certain extent by the stay bolts and other fastenings, and the separating force exerted by the steam pressure.

In order to obtain definite information that would give the amount and direction of these movements, your committee conducted such experiments that would give this information, and though all data desired were not obtained, yet definite results were accomplished. Starting with the idea of determining only the relative movement of the two sheets, an apparatus was devised, consisting of a casing, containing parts making steam-tight joints, screwed in the outer sheet and a plug screwed in the inner sheet. Driven on this plug was a length of seamless steel tubing at the free end of which was attached a brass cap, the brass cap being free to slide against a half-round ring, provided to guard against the non-alignment of holes in inner or outer sheets, and so as either sheet moved in the horizontal plane a steam joint was always kept. Resting on the half-round ring and kept in contact with it by means of a spring under proper compression, was a ground piston capable of being moved up or down, obtaining by this means a steam joint if any movement in this direction took place. These three joints thus provided for any movement whatever that might take place. To provide for the relative movement of the sheets, the table for holding the papers on which the records were made was attached to the casing held by the outer sheet, and the recording levers were connected to the plug fastened in the inner sheet by means of a rod entirely free of all restraining pressures. For the movement of the sheets in a horizontal plane, a pantagraph of usual construction with a ratio at the pencil of approximately eight times the movement at the moving point, and for the vertical movement a simple lever also with a ratio of approximately eight to one, were used.

In addition to the information given by this apparatus, the temperatures of the fire-box and the outer sheet should be known and an attempt was made to obtain this data, but, due to the difficulties encountered, the attempt resulted in failure.

In conducting the trials, two passenger engines, one of the Belpaire and the other of radial stay construction of modern type, which had just passed through the shops for repairs, were selected, and the points of greatest stay bolt failures obtained from the record sheets of these types of engines. Three or four points depending upon the construction of the boiler were selected from each of the four sets of sheets comprising the fire-box. After the necessary work had been done on each boiler — which included one injector in proper working order, the throttle valve in good condition, the valves, piston and cylinder heads removed to allow free passage of steam when the throttle was opened, and a measuring device placed in each hole of one of the four sets of sheets — the preliminary data were observed and the fire started in the boiler, steam being raised as quickly as conditions would allow. The method of urging the fire was that found in ordinary engine-house practice, and consisted of a steam blower supplied from the engine-house piping, which was used until the boiler pressure was high enough to supply steam for the blower.

Readings were taken at frequent intervals until a steam pressure of 25 pounds per square inch was reached, after which they were taken at intervals of 30 pounds until the normal pressure was obtained, at which point the pressure was allowed to remain stationary for ten minutes, so that the different parts of the fire-box might obtain the proper temperature and thus be in a state of rest. At the end of this period, the throttle was opened for ten or twenty minutes, blowing off approximately two gauges of water, keeping steam as near the working pressure as possible. This does not give the intermittent action of using steam in actual practice which may affect stay bolts to some extent, but represents, as near as could be obtained, service conditions. After readings had been indicated on the records, the injector was applied to restore the water used while the throttle was open, not attempting to keep the steam pressure up, as in this way the greatest reduction in temperature of the sheets could be obtained. When the usual readings had been recorded and steam pressure had been restored, the fire-door was opened for five minutes to obtain a maximum condition to represent the opening and closing of the door while on the road, and which would show distinctly on the record sheet any movement due to this cause. After this period, the fire was withdrawn from the fire-box and the throttle opened, allowing about fifteen minutes for reducing the pressure to zero, and at this point the blow-off cock was opened, the water allowed to drain, and the boiler, with all devices in place with fresh record cards, left to cool, thus obtaining the action taking place during cooling as well as heating.

[Drawings of the apparatus used and tables showing the results of the tests were included in the report.]

The greatest movement, as might be expected, occurred at the crown sheet and upper corners of the side sheet, but very little took place at the top of the back head where some amount might be looked for, even though this is the fire-box sheet of lowest temperature. Practically no movement whatever was shown at the lower corner of the side sheets. This may be explained by the lower temperature, the points measured being in the bed of the fire. The restraining effects of the heavy mud ring and its fastenings probably also contributes to this result.

The greatest movement obtained in a horizontal plane was at point F (center of front edge), on the radial stay crown sheet, where the difference in movement of the two sheets amounted to 0·08 and 0·09 inch — about $^3/_{32}$ inch — with rising and falling temperature respectively, and to 0·06 inch in the vertical plane at point B (near center of back edge), on radial stay crown sheet with falling temperature. From this it appears that the relative movement is very small, and, from a further examination of the table in but few instances did the difference in movement of the two sheets greatly exceed 0·015 inch ($^1/_{64}$ inch).

There is very little difference in movement between the radial stay and Belpaire types of boilers.

Some claim that a movement of the sheets takes place as the steam pressure varies or when the fire-door is opened during the operation of firing, but referring to the cards, no signs of such movement can be detected. This movement was particularly looked for as the tests progressed, but as no indications were observed, and as conditions were aimed to give results much more severe than would be derived in practical work, it must be assumed that any such movement is infinitesimal in amount. In some of the diagrams, a reversal of direction is shown to have taken place and this means the bolt has undergone a reversal of strain which, in the horizontal plane, indicates a bending action taking place. However, little of this reversing took place after the boiler was under normal pressure for ten minutes. Nevertheless, it is interesting to know that the line of fracture of broken stay bolts closely agrees with the general direction taken by the sheets in expanding as indicated by the diagram, and that failure is probably due to a repetition of small movements over a long period and aided by the tension exerted by the separation of the sheets.

In conclusion, your committee believes that flexible stay bolts are giving very satisfactory service where the design is good and the conditions are favourable. The only unfavourable conditions which seriously affect the service are bad workmanship and water containing hard scale-forming material; the first condition being less serious than the second.

It has been shown that there is a definite movement of the sheets, of small amount, from the cold boiler to the working pressure temperature and that the movement has an effect upon the life of the bolt. Any small changes of temperature, caused by the operation of the injector, reduced steam pressure, or the opening of the fire-door, produce a movement of the smallest amount.

Your committee believes that it is wise to substitute flexible bolts at the point where experience shows the greatest breakage of rigid ones, and that no hard and fast rule can be laid down to show where this occurs, as this location is affected by the design of the boiler; that the flexible bolt must be one designed to minimize the difficulty from incrustation; that it must be of proper strength and with sufficient clearance in its fittings; and finally, that the design should, if possible, be one to facilitate examination. With these conditions observed, your committee is convinced that the flexible bolts will give great relief from the present troubles.

PROCEEDINGS

OF THE

SEVENTH SESSION

WASHINGTON : MAY, 1905

4th SECTION. — GENERAL.

[385 .517]

QUESTION XVI.

PROVIDENT INSTITUTIONS

General principles of plans for the retirement and insurance of railway employees and workmen.

Reporters :

Countries using the English language. — Mr. M. Riebenack, comptroller, Pennsylvania Railroad.

Other countries. — Mr. Marcel Lemercier, docteur en droit, secrétaire général de la Compagnie des chemins de fer de l'Est français.

QUESTION XVI.

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— II : Note on the provident institutions of the South Australian State Railways, by John PICKERING 113

PRELIMINARY DOCUMENTS.

Report No. 1 (countries using the English language), by M. RIEBENACK. (See the *Bulletin* of December, 1904, p. 1693

Complement to report No. 1, by M. RIEBENACK. (See the *Bulletin* of January, 1905, p. 95.)

Report No. 2 (other countries), by Marcel LEMERCIER. (See the *Bulletin* of April and December, 1905, pp. 1469 and 2423.)

See also the separate issues (in red cover) Nos. 18, 23 and 44.

SECTIONAL DISCUSSION

Meeting held on May 10, 1905 (morning).

Mr. Émile HEURTEAU, president, in the chair.

The President. (In French.) — The business before us is to discuss two reports about " Provident Institutions ", one by Mr. Marcel Lemercier and the other by Mr. Max Riebenack. The heading of the question is as follows : *General principles of plans for the retirement and insurance of railway employees and workmen.* But the reporters, and no one will blame them for it, have seen fit to investigate not only pensions and provident institutions, but in a general way, all institutions founded, subsidized and encouraged by railways, for improving the moral and worldly welfare of their employees.

We shall first listen to each of these two gentlemen summarizing his paper, and after that, our discussion will prove more fruitful.

I now call upon Mr. Riebenack.

Mr. M. Riebenack, *reporter for countries using the English language.* — Mr. President and Gentlemen : Investigations were pursued and report compiled from the standpoint of the use of the term " Provident Institutions " in its widest application to provident endeavor in connection with the railway service in English-speaking countries. As announced in the report, this course was taken for the purpose of laying before the present session of the International Railway Congress a compendium on all salient factors generally conceded to be the main avenues through and by which the railway companies are enabled to get on closer and more intimate terms with their employees. The aim has been to give facts concisely and clearly, based on authoritative replies received from the railways and other sources of information with which communication was had in relation thereto. A mere cursory glance at the make up of the report, will show the great variety of information comprehended on different provident undertakings, and the different methods observed in the framing of replies by the interested roads.

The report has been, however, devoted, for the most part, to what may be styled the chief provident undertakings, namely, " insurance and retirement " provisions.

It has not been deemed necessary to comment upon the practices common to commercial insurance companies, for these are pretty much the same in all countries, and with which all are generally familiar.

As will be noted, the subject of " insurance " in connection with the railway service in the United States has been divided into five different heads, namely :

a) Life and Accident Insurance;
b) Mutual Insurance;
c) Endowment Insurance;
d) Railway Relief Department;
e) Employees' Relief Association.

This division was arbitrarily made, with the view of conveniently and conspicuously emphasizing the points of difference in the characteristics common to the various forms of insurance undertakings conducted by or in connection with the several railways.

Before entering upon direct comment upon the data embraced by the report to the Commission, your attention is respectfully directed to an announcement of the various provident institutions and measures treated therein. These will be next stated in summarized form, and in the order of their presentation in the report, namely :

a) Insurance and Relief Provision;
b) Pension or Retirement Provision;
c) Superannuation Provision;
d) Hospital Service;
e) Savings Funds;
f) Co-operative Capital Stock Purchasing Plans;
g) Young Men's Christian Association Railroad Branches;
h) Libraries and Reading Rooms;
i) Literary Institutes;
j) Loan Provision;
k) Public or Private (Outside) Provision;
l) Leave Allowance;
m) Miscellaneous Provision (including minor provident effort, such as Rest Rooms, Dining Clubs, etc.);
n) Railroad Orders and Brotherhoods;
o) Palace or Sleeping Car Companies;
p) Express Companies;
q) Railway Mail Service;
r) Welfare Work.

While the real keystone of the arch of provident institutions is the composite made up of the provision made and sustained at railway expense, for sick, injured, and aged employees, and designated beneficiaries in the event of their death, as comprehended in respectively " insurance and relief ", " pension or retirement ", and

" superannuation " plans, the other undertakings just offered obviously form distinct and sound links in a continuous chain of provident effort clearly calculated to create mental, physical, social and spiritual betterment; and they also serve to accentuate the force and utility of the general proposition. You are respectfully requested to consult the two parts of the report, which, for sake of convenience, may be designated as " General Report " and " Supplemental Report ", and which the Commission has styled " Report No. 1 " and " Complement to Report No. 1 ". These reports are fully indexed, and a moment's consultation of the indices, will suffice to point the way to any particular provident undertaking in any of the countries included in reportorial investigation.

Insurance plans will be discussed in the order given in the report, as already stated, and may be briefly described as :

Life and Accident Insurance. — This is insurance provided by regular or commercial insurance organizations conducted independently of the railway companies. The latter contract for the insurance under varying conditions, and it is provided the employees on differing terms. This form of insurance will be found treated at pages 12 to 17 (¹), both inclusive, of the General Report, and at pages 121 to 133 (²), both inclusive, of the Supplemental Report. It may be observed that some of the roads conduct their own system of accident insurance, and these undertakings while patterned after the practices of the commercial companies, are also invested with peculiarities which the roads concerned may deem suitable for their own requirements.

Mutual Insurance. — The presentation for Mutual Insurance will be found at pages 18 and 19 of the General Report. These Mutual Benefit or Relief Associations, so-styled, are characterized by features identifying them more or less closely with commercial insurance practices, especially as regards the " risks " involved, also by reason of working exclusively along accident and death lines. As a matter of fact, they could be consistently grouped with the so-called " Employees' Relief Associations " mentioned in the said General Report, and of which mention will be made later on. Their separation from this group was dictated largely by the desire to bring out the salient elements of this particular class of railway insurance.

Endowment Insurance. — This is in no sense similar to the endowment insurance provided by regular life insurance companies. The insurance furnished grows out of an endowment or principal sum given by one or more persons; from the interest, or net proceeds of such interest, is created and maintained a fund out of which are made payments to designated employees when affected by sickness, accident, or old age, and to specified beneficiaries in the event of their death. This feature is offered

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(¹) Vide *Bulletin of the Railway Congress*, No. 12, December, 1904, p. 1702 to 1707.

(²) — — — — No. 1, January, 1905, p. 97 to 109.

at page 20 of the General Report. At the page named, will be found presented a brief outline of the endowment fund created by the well-known philanthropist, Mr. Andrew Carnegie, amounting to $4,000,000, providing accident and death benefits and pension allowances, and which concerns employees of companies with a standing as constituent members of the Carnegie Interests.

Railway Relief Department. — When the term "Railway Relief Department" is used in the report, the idea sought to be conveyed is, that the roads involved are directly, substantially, and continuously identified and concerned in the management and operation of the funds. They are thus differentiated from the numerous insurance societies organized and maintained by the employees themselves exclusively, and in the management of which the railroad companies have no voice, although they may from time to time make liberal contributions towards their support. A railroad relief department viewed in this light, represents an organization invested with the best attributes of the so-called mutual benefit association, in the management and conduct of which both the railroad concerned and its employees mutually and jointly co-operate to bring about well-defined and common ends — fixed benefit allowances during disablement from sickness or accident, and payment of a stipulated sum of money to designated beneficiaries in the event of death.

The report includes nine (9) roads identified with the conduct of relief departments, and these I will next announce, together with certain statistics relating to each :

NAME OF ROAD.	Mileage.	Number of employees.	Number of members.	Average annual expenditure.
Atlantic Coast Line Railroad	4,139	17,512	8,129	$82,763·83
Baltimore & Ohio Railroad	4,322	54,600	41,783	375,153·75
Chicago, Burlington & Quincy Railway	8,324	38,350	22,141	332,504·71
Cleveland Terminal & Valley Railroad	88	1,088	995	9,304·42
Lehigh Valley Railroad	1,398	18,621	6,505	35,547·55
Long Island Railroad	392	6,145	4,700	20,400·00
Penna. System East of Pittsburgh	5,852	110,327	76,507	750,989·53
Penna. System West of Pittsburgh	5,062	49,202	26,644	381,260·40
Philadelphia & Reading Railway	1,468	23,732	18,951	241,765·54
Totals	31,045	319,577	206,355	$2,229,689·73

The figures given in the table pertain to the year 1903. The report deals with these railway relief departments at pages 21 to 41, both inclusive. The departments with the several interested roads are patterned after those in operation by the Baltimore & Ohio and the Pennsylvania Railroads Companies, which are given at pages 22 to 26, both inclusive, and 31 to 39, both inclusive, respectively, in the General Report.

In this connection, permit me to call attention to the fact, that I have had prepared a special exhibit for the Relief Department of the Pennsylvania Railroad Company. It embraces litterature, pamphlets, forms, etc., a study of which will afford a clear insight into the practical workings of the plan. I shall be glad to furnish copies of these papers to any one desiring them, if they will leave their address or write for them, also similar information in regard to the Pension Department and Saving Fund of the Company.

Another very interesting statistical fact in connection with the operation of railway relief departments is, that while their combined average annual disbursements aggregate in round figures $2,230,000, their combined disbursements since organization approximate $37,150,000.

During the eighteen years' operation of the Relief Department of the Lines of the Pennsylvania System East of Pittsburgh, to the end of 1903, benefits were paid for 469,000 cases of disablement for periods ranging from one day to seventeen years, while 8,531 families of deceased members received death benefits varying in amount, from $250 to $2,500, according to class membership. The members numbered 19,952 on December 31, 1886, and, as already stated, numbered 76,507 at the close of the year 1903, or about 69 per cent of the total number of employees, and included nearly all those who, by reason of age and physical condition, were eligible to membership. The total disbursement during this eighteen-year period, inclusive of $148,662·15 for Superannuation allowances, and $1,815,641·54 for Operating expenses, amounted to $13,517,811·47.

Employees' Relief Associations. — These are, as a rule, small societies, organized among the employees themselves, exclusively, and conducted wholly by themselves, the railway companies with whose service such employees are identified, having no voice whatever in their affairs, although in some instances the companies contribute irregularly, and under varying conditions, to their support. A few of these associations have been offered, by way of illustration, at pages 41 to 44 of the General Report.

Among the railways of the British Isles, these insurance organizations are conducted under such general titles as : " Accident Fund ", " Sick Society ", " Sick and Funeral Allowance Fund ", " Friendly Society ", " Insurance Society ", etc. The organizations usually receive financial and other aid from the railways with which they are identified. In some instances, organizations combine provision for sickness, accident, old age, and death. Membership is in many instances compulsory. The principle underlying the operations of the institutions is very similar. The subject is given at pages 48 to 53 of the General Report, and pages 125 to 133 of the Supplemental Report.

It may be observed that all representative railways of Great Britain provide Friendly Society insurance, in some form, for their employees. Sundry Parliamentary enactments, from time to time, such as the Friendly Societies Act, the Employers' Liability Act, and the Workmen's Compensation Act, stand as Government guarantees for the working-man's protection, and many of the roads have created their own insurance schemes to take the place of legislative requirements, it always being a pre-requisite that the railway undertaking shall make as good or better provision than is afforded by Parliamentary legislation, otherwise the employees may avail themselves of the latter. The undertakings previous to inauguration are submitted to and have the approval of the Government's Registrar of Friendly Societies, and this officer is furnished periodically with reports and statements exhibiting the results of their operations along all lines.

As a source of general information, attention is invited to the tabulated data presented at pages 122 to 124 of the Supplemental Report, as regards " insurance and retirement " provisions among the railways of the United States.

Pension. — Pension Departments in the United States possess the same general characteristics, all being patterned after the plans adopted by the Baltimore & Ohio and the Pennsylvania Railroad Companies, only merely nominal differences obtaining, such as are necessitated by physical and financial conditions of the interested roads.

The objects of the departments are uniformly to provide for compulsory retirement from service at 65 or 70 years of age, with anywhere from ten to thirty years' continuous service, on a fixed pension allowance, computed, usually, at one per centum of the average monthly pay for the ten years next preceding retirement, for each year of service. Involuntary or compulsory retirement takes place between ages 65 and 70, and voluntary retirement, growing out of incapacitation, between ages 61 and 69 years.

Summary, by groups, of age limit provisions by railroads in the United States conducting pension departments.

GROUP.	Number of employees.	Entrance age (years).	Voluntary retirement age (years).	Involuntary retirement age (years).
Group A	126,799	35 to 45	61 to 69	70 (sedentary). 65 (active).
— B	46,378	45	Under 65	65
— C	2,676	...	Under 60	60
— D	4,454	35 to 45	60 to 64	65
— E	11,953	35 to 45	65 to 69	70
— F	228,040	35	65 to 69	70
— G	33,307	35	65 to 69	70

The distribution of railways in the groups just named is

Group A :

Atlantic Coast Line Railroad;
Houston & Texas Central Railroad;
Illinois Central Railroad;
Oregon Railroad & Navigation Company;
Oregon Short Line Railroad;
San Antonio & Aransas Pass Railway;
Southern Pacific (Pacific System);
Southern Pacific (Sunset Route);
Union Pacific Railroad.

Group B :

Baltimore & Ohio Railroad.

Group C :

Bessemer & Lake Erie Railroad (in connection with the Andrew Carnegie Endowment Fund).

Group D :

Buffalo, Rochester & Pittsburgh Railway.

Group E :

Central Railroad of New Jersey.

Group F :

Chicago & Northwestern Railway;
Penna. System East of Pittsburgh;
Penna. System West of Pittsburgh;
Philadelphia & Reading Railway.

Group G :

Delaware, Lackawanna & Western Railway.

Referring to group F roads, for which the maximum age limit for admission to the service is given as 35 years, it may be stated that it is optional with the Board of Officers of the interested Department to recommend that the Board of Directors authorize the re-employment of former employees over 35 years of age and not out of the service more than three years, and of the employment of persons at any age where the service for which they are needed requires special or professional qualifications.

A prominent characteristic of railway pension funds in the United States is, that the undertaking is wholly financed and supported by the railway companies concerned, the beneficiaries making no contribution whatever thereto. The financial demands on some of these funds are met by setting aside originally a certain amount as an investment, the interest accruing therefrom constituting pension or working funds, these amounts being, in some cases, supplemented by a provision for a further maximum appropriation when necessary; in other cases, the railway company simply assumes responsibility for a maximum annual disbursement.

Data on pension undertakings furnished by eighteen (18) roads in the United States, show sixteen (16) pension funds in operation, and two (2) practically ready for introduction, while, besides, several roads announce plans either under consideration, or in course of preparation.

The roads reporting pension funds embrace upwards of 50,000 miles of railway, or about twenty-four (24) per centum of the total railway mileage of the country, and approximately 500,000 employees, or about thirty-eight (38) per centum of the total number of employees of all roads in the United States.

The funds represent an aggregate annual appropriation not to exceed $1,350,000, when necessary to make payment of pension allowances, while eight (8) of the roads set aside originally, as the basis of pension or working funds, an amount aggregating about $600,000. Twelve (12) of the roads have expended since organization, to the close of 1903, an aggregate of $2,500,000, and the roads concerned were carrying on their pension rolls, the names of 3,200 pensioners at the end of 1903, while the aggregate mortality among pensioners, since fund organization, numbered 1,150.

As a rule, pension plans in Great Britain call for contributions by the employees, and membership is compulsory. Those on the " wage " list only are affected by these undertakings. Under this arrangement, there is entailed refunds where a non-pensioned member dies, or where a member is dismissed or leaves the service. The retirement ages are lower than with the American roads, but the service period is very similar.

Superannuation. — Superannuation provision with the railways of the United States is confined exclusively to the lines of the Pennsylvania System East of Pittsburgh, Pa. The allowance grows out of membership in the Relief Department, and is in a measure an additional pension allowance. The " Relief Fund Surplus " is the nucleus of the provision, and the accrued interest on this " surplus " is the basis for calculating allowances. The subject is presented at pages 73 and 74 of General Report, to which notice is invited.

From a transportation point of view, superannuation finds its fullest and highest expression and observance with the English railways. In Great Britain, the term

" superannuation " is distinguished from the term " pension " in that the English superannuation fund has for its membership the " salaried officers and in-door staff ", as a rule, and, in that light, embraces only such employees as are remunerated by an annual salary, in contradistinction to weekly-wage or other form of remuneration than annual salary.

Formation of superannuation funds in Great Britain is usually provided by Parliamentary enactment under what are styled " General Powers Acts " pertaining to interested railways.

Financing of the funds is on uniform lines, consisting for the most part of prescribed membership payments, commonly 2 $^1/_2$ per centum on salaries, with a corresponding aggregate subscription by the railways, with interest on surplus placed in charge of the railway concerned, or otherwise invested.

Retirement takes place at ages 60 to 65 years, regularly, with anywhere from ten to thirty years' service or membership, and also upon permanent incapacitation, before reaching those ages, with ten or more years' service or membership.

Refunds, on a common basis, are provided in event of death, either previous to or while enjoying superannuation benefits.

Commutation of allowance obtains, on the basis of a payment of a lump sum in lieu thereof.

These superannuation funds for British railways will be found at pages 75 to 82 of the General Report, and 144 to 147 of the Supplemental Report, and your attention is respectfully invited to these pages.

These " insurance and retirement " undertakings being the particular ones for consideration at this convention, more time will not be taken up in detailing the various features of the other forms of provident endeavor offered in reports. They are, as already remarked, important parts of the whole scheme of " railway provident endeavor ", and it would no doubt prove highly interesting to accord them as much attention in session as possible. It will suffice now, for practical purposes, to merely announce their location in the reports, which will place the members in position to raise any questions that may suggest themselves :

UNDERTAKING.	General report, page	Supplemental report, page
Hospital service.	83 to 89	147
Saving funds.	90 to 96	149
Co-operative stock scheme.	96	150
Y. M. C. A. railroad branches	98 to 101	152 to 153
Libraries and reading rooms	103 to 105	153 to 154

UNDERTAKING.	General report, page	Supplemental report, page
Literary institutes	105	155
Loan provision	105	157
Public or private provision	107 to 109	158 to 163
Leave allowance	110	163
Miscellaneous provision	111 to 112	164 to 166
Railroad orders and brotherhoods	113	167
Palace or sleeping car companies	115	168
Express companies	115 to 116	169 to 185
Railway mail service	...	186 to 188
Welfare work	...	189

The movement looking to the improvement of the mental, social and spiritual welfare of employees generally, and the making of provision for their physical requirements during disablement from sickness or accident, incapacitation from old age, and for their dependants and designated beneficiaris in the event of their death, is now firmly rooted and widespread in all English-speaking countries, and all these elements of personal betterment have become highly important matters in the administration and operation of the more prominent railways. In many instances, in the United States, roads are deeply interested in " relief departments " and " pension " undertakings, and are deterred from inaugurating similar plans on behalf of their own employees by the great expense entailed in their conduct only.

It does not seem possible to harmonise the pension plans adopted in English-speaking countries, for the reason that the undertakings in vogue with the railways in countries other than the United States involve contributions by employees participating in the benefits extended, while in the case of the plans conducted by the railways of the United States, the participating employees make no contribution whatever, the financing of the funds and the entire expenditure for retirement allowances being borne by the roads exclusively. Moreover, with the American plans there is no distinction drawn between the classes or grades of employees eligible to pension allowances, all employees sharing alike, on the common basis.

The President. (In French.) — Before we proceed to discuss the very interesting report, a summary of which we have just heard, I should like to ask Mr. Riebenack one or two questions upon points which need further elucidation.

In alluding to the organization of pensions on some American lines, you have spoken of the age at which the staff join, and you have told us that the age varies between 35 and 45. Does that mean that those who enter the companies' services later than between 35 and 45 do not share in the pension fund ?

Mr. M. Riebenack. — They are not admitted after 45 years on some of the roads; not after 35 on the Pennsylvania Railroad system. We admit none into the service, that is, who are over 35 years of age. On some of the other roads that have pension features, they are permitted to employ inexperienced men not over 35 and experienced men up to 45 years of age.

The President. (In French.) — Then the maximum age limit for admission into the company's service is 45 years.

Mr. M. Riebenack. — Yes. I would say this, however, that if a man is over 35 years of age, having been in the service of the company, if he goes out, he can come in again within three years by making application to the proper officers who are charged with carrying out the pension regulations. There are also exceptions made in case of professional men, such as general solicitors or specialists of any kind, engineers of high standing; they can be brought in by permission of the Board of Directors, who make a special exception in their favour. Otherwise every employee is limited on our system to 35 years of age, and on some roads to 45.

The President. (In French.) — As a matter of fact, at what age do employees enter the service ?

Mr. M. Riebenack. — At the time we organized the pension department, our average age was 27 years; that was the average of admitting men to the service. That was prior to 1900; and the average age is not any higher now.

The President. (In French.) — I should like to ask you further how the funds are supported. Are the sums handed over by the companies proportionate to the wages of the employees ? Do the pensions depend likewise on the average wage of the last few years and lastly, do you make it your business, or does some one take care, to estimate exactly whether the payments so arranged precisely cover the risks ?

Mr. M. Riebenack. — I will give you a short history of the relief department, following up what is going to pensioners out of the surplus that is invested as the result of the operation of the relief fund, which they get in addition to pension, and which we term " superannuation ".

The relief department was organized some eighteen years ago. The general principle on which it is organized is that the employees contribute a certain amount of money in five classes, the first class 75 cents, and so on up. They contribute to that monthly, and that is taken off of their payrolls, that amount of money. That money that is so received, goes into the contribution account from the employees to the fund. All benefits are paid out of that fund to the beneficiaries, for sickness or death. The amount of the benefit is from $250 to $2,500. The bases on which the rates were made, are a little different from what gentlemen in Europe are accustomed to. We found as early as 1874, under the administration of Colonel Scott, that an effort was being made to benefit the employees in some way. That was on the Pennsylvania Railroad, and it resulted in the employment of actuaries, who went into the subject thoroughly, and it was then given up, as it was considered to be too arduous a work. In 1880, the Baltimore & Ohio Railroad organized a relief department to fix rates for the different classes. Mr. John W. Garrett had employed a gentleman who was very enthusiastic on the subject, and he went into it very carefully. We conferred with him in organizing our department; I mean a committee of railroad officers of the Pennsylvania Railroad. The result was we adopted their rates on the strength of his experience (extending over five years), and also because he persuaded us it would hold out, and that we could meet the obligations under it. We started in and had considerable trouble at first, but finally we got started in 1886. We gave the employees six months to come in, and we took in everybody at that time who wanted to join. In other words, it was a scoop net which took everybody in. The result of the rates proved entirely satisfactory, and has enabled the employees, as between their contributions and what was paid out to them in benefits, to accumulate a permanent sum which amounts now to $751,000. This is being added to every three years, whatever the surplus will make, whatever the results will be. Our prices are based upon the three years statement of the operations. That surplus is invested at a little over 4 per cent and nets about $30,000 a year. Bear in mind that the pension fund has nothing to do with the relief department. The pension is an obligation assumed by the company to reward its employees; when a man reaches 70 years of age in the service he is retired on a pension. If he is a member of the relief fund, he gets an additional allowance out of this $30,000, which is calculated on the basis of 1 per cent for each year he has been in the relief fund. For example, if he has been in ten years he gets 10 per cent, and so on.

The President. (In French.) — If I understand rightly, there are two separate institutions; on the one hand, the " Relief Department " which is kept going by contributions and this provides an extra pension, and, on the other hand, the Company's pension fund.

Mr. William d'Eichthal, Local Railway of the Landes District, France. (In French.) — Now we are dealing with the Pennsylvania only.

Mr. M. Riebenack. — Yes, I make that distinction.

The President. (In French.) — What percentage does the pension bear to the wages?

Mr. M. Riebenack. — They get 1 per cent for every year they have been in the service of the company.

The President. (In French.) — And the same applies to the relief fund?

Mr. M. Riebenack. — The relief fund is not so old; it is only 18 years old.

The President. (In French.) — So the relief fund is entirely distinct from the pension fund?

Mr. M. Riebenack. — Yes Sir.

The President. (In French.) — If an employee dies does the pension fund act like an insurance?

Mr. M. Riebenack. — No, Sir. The pension fund, properly speaking, is not invested with any of the regular or other features commonly incident to regular or other form of so-called insurance undertakings. The only element of insurance involved is that arising from the circumstance that the pension allowance insures (protects) the retired employee against want and privation during his declining years, by providing him with a stipulated money allowance, paid monthly, from the immediate and exclusive revenues of the railway corporation, the interested employee making no contribution whatever therefor. Beyond this, there is no element of insurance involved. The payment of the pension allowance is made to the retired employee exclusively, during his life, and at his death it ceases altogether the members of his family and other heirs at law being wholly excluded from participation therein. In short, the several railway companies associated in joint administration of the pension fund extend the privilege of retirement, on pension allowance, purely as a matter of policy, as an evidence of corporate regard for the welfare of aged and permanently incapacitated employees who shall have rendered faithful and efficient service, and the pension fund, so-called, consists wholly of corporate revenue, and is, therefore, subject to corporate regulation and control exclusively. Retired employees receiving superannuation allowance are permitted, by paying the prescribed contribution therefor, to retain title to death benefits extended by the Relief Fund; and such superannuation allowance, it may be observed, is made from what is styled the Superannuation Fund, the nucleus of which is the surplus, if any, arising from operation of the Relief Fund. In other words, only members of the Relief Fund participate in what is called the " superannuation allowance; " hence only members of the Relief Fund enjoy the advantage of passing their " insurance " or, as they are termed, " relief fund benefits " to designated beneficiaries.

The President. (In French.) — Is this a fund in which the Company brings together capital raised from payments in proportion to the wages paid? Are the pensions paid over by this fund proportional to the average wage? Lastly, do the payments on the one hand and the pensions on the other balance and is the fund self-supporting? I should be much obliged if you would kindly answer these different questions.

Mr. M. Riebenack.— In the case of the Pennsylvania Railroad Company, the money for paying the pensioners is provided by the stockholders of the company, they giving authority to the board of directors to make an expenditure of $390,000 annually, not to exceed that. The manner of paying this to the pensioners, is exactly the same as it was when they were actively in the service; that is, there is a pay roll made out for the pensioners which follows the railway division the employees were on, and they are paid by the same officer from whom they formerly received their wages.

The President. (In French.) — But is this payment a fixed proportion to the average salary of the employees?

Mr. M. Riebenack. — The payment of the employees is proportionate to the annual wages they earned during the last ten years of their service.

The President. (In French.) — What is the proportion between this average salary and the pensions?

Mr. M. Riebenack. — It depends on the length of service. If he has been thirty years in the service, he gets 30 per cent of his pay, 30 per cent of the pay he received on the average during the last ten years of his service with the company.

Ths President. (In French.) — It seems to me from what Mr. Riebenack has just told us that we are not dealing with a fund such as we understand it to mean in Europe; it seems to be a special financial institution holding money which is paid over and accumulating capital to provide pensions out of the interest earned on this capital; it would seem to be simply a case of allowances paid over by the company to non-workers out of sums entered in its annual balance sheet.

Mr. M. Riebenack. — No; not voted every year; the last was three years ago.

The President. (In French.) — For how long?

Mr. M. Riebenack. — Oh, indefinitely. But we are not to exceed that amount of money. The disbursement is charged in the regular operating expenses, as it was paid out to those men when they were in the service.

The President. (In French.) — Then you have not any fund in which an amount of money is accumulated every year to pay the pension?

Mr. M. Riebenack. — The pension is paid by the company and goes into its operating expenses. The only restriction to it is that the operating officers shall not expend more than $390,000 in any year; and we have not exceeded that any year, we are always within the limit. We do not require a fund because the company furnishes it the same as it pays the wages.

The President. (In French.) — Is the amount all spent each year, whatever the number of employees? The number of men who retire each year is not constant, and the number of years they have been in the service is not the same. How is the expenditure required for each year always an invariable amount of $390,000?

Mr. M. Riebenack. — That is a fixed maximum figure. This amount of $390,000 has been invariably fixed and has not yet been exceeded.

The President. (In French.) — Do all employees without distinction share in these pensions or only those in the out-door service?

Mr. M. Riebenack. — Every employee that is on the pay rolls of the company. We have 117,000 employees east of Pittsburgh and every man is eligible to this pension if he is 70 years old or, if he is incapacitated, as soon as he reaches 65.

The President. (In French.) — We might now pass on to Mr. Lemercier's report upon non-English speaking countries.
I now beg to call upon Mr. Lemercier for a summary of his report.

Mr. Marcel Lemercier, *reporter for countries not speaking the English language.* (In French.) — The report I drew up does not deal solely with provident institutions and superannuation funds properly so called, but with all the measures taken to benefit railway servants. I divided my paper into four chapters :

The first chapter concerns matters not appertaining to assurance institutions, *i. e.* all measures and institutions supported by employees with the idea of promoting the welfare of the working staff. For instance, I allude to the free housing of certain classes of employees; lodging allowances granted to others who cannot occupy the dwelling accommodation supplied by the Company; assistance extended by some companies to stores and provision societies which lay themselves out to provide the men with the necessaries of life, food, etc., at specially low prices, of good quality and full weight; various kinds of discounts and bonuses; warehouses and storehouses; support granted to mutual benefit societies; assistance given to employees in times of stress; travelling facilities accorded on a very liberal scale to employees and their families, to children going to school or to wives travelling to get supplies at a neighbouring market.

Similarly I allude to the reduced charges made to the staff in refreshment rooms; baths and douches placed gratuitously at the disposal of drivers and firemen, lastly to all the hygienic and prophylactic measures taken to safeguard the staff against the illnesses that may attack them : especially the measures taken to protect the children of employees against tuberculosis, and to prevent the employees themselves from taking to alcohol which is one of the main feeders of hospitals, cemeteries and lunatic asylums.

I do not think we should gain anything by my delaying over these railway benefits; at least I need only draw your attention to the importance of free lodging, which, with some companies, especially in France, is regarded as constituting an extra wage, and this extra wage is allowed for in calculating the retiring pension.

Similarly it is interesting to note how help, though small in amount, given by a company to stores or cooperative societies, may improve the material welfare of the staff. The allocations for school education, for libraries, clubs and similar institutions are, moreover, of great value from a moral standpoint.

I may further call your attention to the facilities granted to the staff in the matter of uniform. Some administrations go to considerable expense in this direction.

From a different aspect, that of helping their men through certain crises in life, several companies have organized permanent assistance for plenty of families by granting periodical allowances, to fathers of families with at least three children dependent upon them, sometimes four under 16 years of age, or even some other relations; the expenditure under this head, for instance in 1903, amounted for the six great French companies to a total of 1,500,000 francs (£60,000). It is a large sum but imitators of our policy have been found in other countries, specially in Spain. Similarly also, there free loans may be granted by some companies, when their servants find themselves in exceptional circumstances which prevent them from meeting proper and necessary expenses.

Lastly, means are taken in some countries to continue the wages of men while they are doing their military service. Special allowances are often made to men when their time is up by many railways, and special facilities are granted to their wives and children to enter the railway service. This is a further very practical and cheap way of helping one's employees.

I shall not waste more of your time over this first part of my report, and shall now proceed to institutions that relate to insurance, beginning with that against illness, which forms chapter II of my report.

In the case of sickness, there are two main systems; one depends upon legal enactments, the other rests solely on institutions founded by employers and due to their direct initiative. The countries that go in for compulsory insurance are more especially : Germany, for working men, Austro-Hungary and Switzerland. In the other countries, Belgium, Denmark, Spain, France, Italy, Holland and Sweden, there is no such thing as a law making assurance against sickness obligatory. But whether considering countries where obligatory assurance exists or where it does not exist, it may stated, generally speaking, almost without exception, that railway servants who are ill enjoy the following advantages :

If sick, they get free medical attendance from the railway's doctor, they get medicines ordered by him gratis, as well as other medical and surgical necessaries; lastly, they get paid their wages under conditions that vary under different managements and in different countries. On many railways, they are granted full pay, either from the commencement of the illness, or from the third or fourth day, and this full pay is kept up for a certain length of time. Then, they are put on half-pay and, some months later, all pay is stopped. Then, it is considered whether the man's place ought to be filled, or whether it should still be kept open until he can undertake his duties again after a certain time of absence without pay.

I need not give you any more details on this point either, for you will find all the figures in my report and there is nothing special to notice in this respect.

I shall close my analysis of chapter II by stating, that in some countries, hygienic precautions are taken not only against illness, but also against accidents. On some lines, vaccination and compulsory revaccination have been arranged for, to protect the men from small-pox. Similarly, to prevent the spread of typhoid fever and other infectious diseases, some administrations have started departments for bacteriology and micro-biological analysis, arranged anti-alcoholic lectures and endowed beds in sanatoria. In Germany, they have even founded large tuberculous hospitals with money from the workmen's pensions funds.

Now coming to accidents during work, to which subject chapter III of my report is devoted, I may say that, more than in the case of illness, the principle of assurance rendered obligatory by law has spread through many European countries. In Germany, Austria, Norway, France, Belgium, Italy, Spain and Holland, laws of longer or shorter standing have been passed; the earliest was that of Germany which dates back to July, 1884; it was amended in May 1885 and in June 1900, and was the first to establish the principle of obligatory insurance against accidents during work. The other countries, on the contrary, Hungary, Switzerland, Denmark, Portugal, Sweden and Russia, have not yet started obligatory assurance and perhaps never will have it.

Furthermore, it may be said that just as in those countries which have obligatory insurance, so in those which have not, the railway workman is completely protected against accidents during work. Throughout any illness he gets free attendance, either at home or in hospital; he likewise gets medicines and surgical requisites gratis; lastly, he gets at least part of his pay, for it is to be noted that none of the laws passed on accidents during work have ever enacted the payment of full wages that are granted by many administrations even for ordinary illnesses.

Again, the laws on accidents, as also the regulations of administrations not subjected to legal enactments, provide for damages in case of death, when a workman dies as the result of an accident. A pension for life is everywhere granted to his widow, or at least until she marries again; in such case, if the widow desires to marry again, she is granted a final lump sum equal to three years of the pension she was previously getting. Similarly, pensions are granted to the children, often to grand-parents and relations.

I need not continue about accidents during work, in which there is no marked development from the standpoint of the principle of insurance, and I now come to chapter IV entitled : " General principles of superannuation and life insurance institutions, " which would seem to have been meant to be the sole object of this report.

Here I thought it would be interesting to consider the principles of life insurance, because the organization of pensions is infinitely more difficult than to draw up laws and regulations concerning sickness or accidents during work which can be arranged with the help of comparatively simple statistics that can be easily made out. The risks arising from accidents are far less serious and much less difficult to calculate than those arising from old age, premature decay or death. In these circumstances, we have to know how we can insure the staff against these three main dangers.

To effect this, there are various ways. Savings are the first thing that occur to one, but that is not a sufficient method, for a workman can seldom put by anything. Insurance, on the other hand, offers several solutions, for there are many ways of insuring the staff. Speaking generally, there are two great subdivisions of insurance; insurance to cover the risks of old age and premature incapacity, and insurance in view of death to provide a pension for widows and orphans.

To cover these three risks together, incapacity, old age and death, we need mixed insurances to lessen the evils of these two classes of misfortune; this can be secured either by insurance companies with fixed premiums, or by mutual insurance societies, or by syndicate funds due to the initiative of certain associations or of certain groups of employers; or by superannuation funds, founded, managed, controlled by the companies; or finally, by recourse to several of these institutions at one and the same time. In France and in many other countries, the railway companies make little use of insurance companies or mutual societies. Special cooperative societies have developed largely in some countries, but they cannot grant large enough pensions because the individual subscriptions are too small. In Belgium and in France, there are public funds which enable people to take out assurances on easy enough terms, and they are absolutely secure from a financial standpoint, but neither are they free from practical disadvantages.

Most of the companies and managements in Europe has resorted to funds of their own, started and controlled by the companies themselves. These funds are devised to supply pensions or capital for the men, their widows and orphans. They are managed by the employers, sometimes with the help of the staff, and are kept up by periodical payments which come, either mostly or entirely, from allocations granted by the managements. Under given circumstances of time, service and age, an employee has a right to claim his pension or a capital sum. In some cases, he requires, in France for instance, twenty-five years service and 55 years of age, or even 50 only on the Northern of France Railway. Sometimes, the regulations require only a single condition, a certain time in the service, which may be very hard on the fund, *e. g.* ten years on the Emperor Ferdinand Northern of Austria Company; or else, which is contrariwise very advantageous for the fund, there is no condition but advanced age, 65 years, for instance. on the Prussian and Danish State railways.

The regulations usually also provide for anticipated payment of proportional pensions or increased pensions for workmen who have become incapacitated or ill. The ordinary pension is, in many funds, equal to half the average wage of the last five or six years *plus* a fortieth, a sixtieth or an eightieth of the wage for each additional year of service beyond the normal period. The pension almost always reverts to half the amount to the widow and in various shares to any children under age. In some cases, the contributions are repaid with or without interest.

Some regulations contain rather strict clauses, and go so far as to provide for the suspension of pensions already granted or for abrogating them altogether, but the latter is very unusual. Some companies have only one class of pensions, while others have two, one for salaried officials, *i. e.* who form part of the staff and who have a certain amount of authority or responsibility — in a word, all employees and servants who have reached a certain grade — and a second class for the other employees. From a financial standpoint, these internal funds are in a very different position, in that some of them were instituted at a time when the rate of interest was very high. Calculations were based on the permanency of this high rate, and the premiums based on these expectations have proved insufficient, and this may involve heavy sacrifices some day.

After this outline of the various methods of assurance, I thought I ought to analyse the five factors of insurance, so as to enable anyone to see how the funds ought to be established so that they may work normally and regularly. I accordingly considered successively:

1° The *assets assured*, *i. e.* the value of the human capital represented by the employee or workman;

2° The *risk* which is really the actual value of the possible claim;

3° The *cost of the insurance* which ought obviously to be the balance or equivalent of the risks, which is a very difficult matter to estimate, especially in the internal funds of railway administrations;

4° The *indemnity*, that is to say the nature and importance of the necessary payment sufficient to make good the loss caused by the realisation of the assured risk;

5° Finally, the *guarantee*, that is to say the conditions requisite to make the assurance worthy of its name and capable of fulfilling its purpose.

In this respect, the main element of security, for the insurer as well as for the insured, is to effect the absolute equality of the payments and of the risks, in other words, to have an insurance rate based on a true appreciation of the eventual losses. For, in all cases where premiums do not suffice to cover the value of the risks insured, the insurer may find himself unable to pay the indemnities and the insured may find themselves deprived of the advantages provided for in their contract. Assuming that the premiums have been properly calculated, it is also necessary that the funds should be well invested and that auditing should be carried out most stringently. The financial side is one of great importance in these circumstances.

It is thus certain that if a company chooses to have internal funds or even if it promises, without an internal fund, pensions fixed on the basis of the employees' wages and their years of service, in short, if the company undertakes a definite engagement, undeniably it must calculate its position very accurately, and it must arrange with that object its rates, its mathematical reserves and scientific balance sheets on the principles of assurance; it is thus exposed to fairly considerable and even quite considerable risks in some cases. For there are some disturbing factors which play an important part, for instance, the fall in the rate of interest. In Europe, we have seen investments bring in 5, 4 $^1/_2$ and 3 $^1/_2$ per cent now; obviously under these circumstances there are serious trials, the demands upon the funds become very serious. Here is an instance :

The amount of the normal payment to keep a given fund going is 8·70 per cent with interest at 3 $^1/_2$ per cent; if it falls to 3 per cent the payment has to be raised to 9·90. If it goes down to 2 per cent, the payment will have to be raised to 12·80. Instead of that we can reduce the pensions, but then we must presuppose that there is no fixed contract, that is to say, that the regulations are not binding. Or, and this is perhaps the most favourable and least onerous solution, we may put up the regulation age for superannuation.

I have shown at the close of my investigation into the question of finance, how seriously the fall in the rate of interest may affect the position of a fund or of its members. To translate into ordinary language the principal data given in the table on page 248 of my report (¹), it will suffice to draw your attention to three figures. Supposing the fall in interest reacts exclusively either upon the amount of the payments or upon the amount of the pension, or upon the age of superannuation, we find that if the interest falls from 3 $^1/_2$ to 0 per cent, which however is an unexpected and improbable imaginary limit, the company might make good the difference, either by increasing its payments by 149 per cent or by decreasing future pensions by 29 per cent, or by raising the superannuation age by 18 per cent only.

If we suppose, on the other hand, that the rate of interest falls 1 per cent only, it will suffice to postpone the superannuation age by two or three years. This would be an insignificant sacrifice and yet it would mean a large profit at least to the fund.

(¹) Vide *Bulletin of the Railway Congress*, No. 5, April, 1905, p. 1520.

That is easily understood, because by increasing the payments we add to the resources of the fund, but we do not decrease its obligations. By decreasing the pensions, we decrease its obligations but we do not add to its resources. If, on the other hand, we put back the superannuation age, we increase the income and we decrease the obligations.

We can conceive a superannuation fund founded on scientific principles which would have a normal existence, but this normal existence involves the passage of a considerable number of years. Taking for instance 27 as the mean age of entry in joining the fund, which is the case on the Pennsylvania as on most of the French railways, and estimating that life may be prolonged to 101, as the extreme limit, we see that during seventy-four years, the fund ought to accumulate capital to meet the liabilities that will fall upon it at a given moment and mainly on the expiry of seventy-four years. Supposing that each year employees enter the service in the same proportion, that the same number of men join each year, we reach a period of absolute stability, during which the pensioners are divided according to their ages between 74 and 101 in invariable proportions. Then the position of the fund remains stationary. The individuals alter, but their number remains constant and the payments are the same each year. The mathematical reserves likewise remain constant. In such circumstances, we can provide for the payment of pensions by taking not only all the income from capital already collected, but also the payments made each year by the employees; we need no longer increase the capital of the fund which also remains unchanged.

If, for any reason whatsoever, it be decided that the fund will not accept any fresh members, then begins the period of liquidating the fund. Henceforth, the number of pensioners steadily falls, as also do the premiums and the mathematical reserves. A day however comes when the sum of the premiums becomes insufficient to pay the pensions, and then the fund must begin to consume its capital which keeps on decreasing until, theoretically, the last surviving pensioners are paid with its last penny of capital.

This is, so to speak, what an ideal fund ought to be. As a matter of fact, this can only happen provided all the following conditions be fulfilled :

Strict application of scientifically determined rates;
Collection of mathematical reserves scientifically calculated;
Investment of money in securities and shares that do not fluctuate;
Valuation of funds at a rate equal to or lower than that which has been taken as a basis for calculating the premiums.

Lastly, to provide for unforeseen contingencies, such as a fall in the rate of interest, the formation, if possible, of a special reserve to enable the fund to meet all unexpected eventualities.

Unquestionably, there are many funds that cannot precisely fulfil these conditions.

What ought to be done in such an eventuality? Are we to liquidate or reorganise the fund? There are four possible solutions :

One can go on just as before without stopping the entry of new members, without replenishing the fund by any fresh resources and await results. The death-agony will be long drawn out; it will be prolonged by the periodical subscriptions of new members, but on the day when the assets have all been used up, the liabilities will be heavier than in any other case. Compulsory is more onerous than voluntary liquidation; some very sad instances have occurred with institutions other than connected with railway funds.

A second solution : put the fund into voluntary liquidation, *i. e.*, stop admitting new members and use up the capital till the end and get the liabilities taken up by the railway or by some other fund.

There is yet a third solution which lies in voluntary liquidation, taking care to cover the deficit shown, either by an annuity, or by some other means. This is a correct solution but hardly advantageous.

A last solution consists in reorganising the fund by various measures such as increasing its resources or decreasing its liabilities, or also increasing the resources and decreasing the liabilities at one and the same time. I have already said that the least onerous and the most practical solution lies in raising the age limit; this is really the best way and it is the least prejudicial both for the staff and for the company.

Unfortunately this can only be done in the case of fresh adherents, because if there are definitive engagements with old servants, you cannot make them accept new conditions; at most you can only make it to their interest to stay on longer by offering them a bonus or some other benefits. Seeing the extreme difficulties of managing not only internal funds but also all institutions in which the employers, whether companies or governments, promise a pension calculated on the length of service and on the wage, I think it advisable to provide that companies or governments should try to turn towards arrangements which do not involve such definite engagements. Only a few companies are in this position, such as the Madrid Saragossa Railway, the French Eastern and the Bona-Guelma, which have taken care, as the American railway companies have done, to limit the liabilities they can incur. But if this precaution has not been taken, very serious difficulties may arise. You can see this if you look through in the appendices of my report the analysis I have given of fifty-eight different regulations of superannuation and especially at a table showing the statistical and financial results of the different arrangements. You can observe therein the extreme importance of these institutions in Europe. Unfortunately, in the English edition of my report, there has not been time to translate these two appendices (1).

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(1) The English translation of Mr. Marcel Lemercier's appendices to his report appeared in the *Bulletin of the Railway Congress* for December, 1905, p. 2423.

I may point out particularly that the financial appendix shows the total number of employees; the number who have joined the pension fund; the annual income; the payments made by the men; the payments made by the managements, the income of the funds; the expenses; the arrears of the employees' pensions, of the pensions to widows and orphans and all other expenses; finally, the capital in the fund at the close of the year.

In closing this summary of my report, I think myself justified in concluding that especially in Europe and in all the countries about which I have enquired, there are very important institutions that are doing good work especially in the matter of pensions, but that their financial position needs very careful supervision. In closing I draw your attention to the conclusions I draw up in my report.

1° It is desirable, as is already done in most civilized countries, that railway servants should be insured, either on the initiative of their employers, or on their own, against the three risks of premature incapacity, old age and death;

2° Leaving out of consideration any systems of distribution under which a State or a company which has a perpetual concession, may effect insurances without forming a reserve, any superannuation fund intended to guarantee railway servants against premature incapacity, old age or death must be organized and managed on the scientific principles of insurance as they are explained in the present report and summed up more especially at the commencement of the paragraph above, entitled : " The life of a superannuation fund : the reality ";

3° It is possible to organize with the same scientific accuracy, either a fund with individual accounts with or without savings books where the insurer limits himself to fix the amount of the payments without entering into any engagement as regards the amount of the pension or the age of retiring, or a fund with a collective amount or with individual accounts, with or without savings books, where the insurer promises to pay a definite pension when a certain regulation age is reached and fixes the payments to be made in accordance with his engagements;

4° Generally, but especially in the organization of funds which promise a definite pension, prudence requires as far as possible :

a) That the question of age should have that paramount importance attributed to it which the scientific principles of insurance show it actually has;

b) That the company should reserve the right of modifying at any time, even for the members then in service, but not retrospectively, all provisions condemned by experience.

The President. (In French.) — We have perused Mr. Lemercier's interesting report and we have listened to the summary he has just made. Have any of you any particular question to put to Mr. Lemercier?

Mr. Riché, French Eastern Railway. (In French.) — Mr. Lemercier's very able and extremely well arranged report proves most courageously that some insurance funds ought to pay attention to financial reorganization. Incidentally, Mr. Lemercier also points out some fundamental reforms which appear to him to modify the difficulties that this financial reorganization might encounter and smooth over the pitfalls it might cause.

I should like to convince you that if we leave the financial question on one side and look at things from a purely moral standpoint and consequently one of general interest, there are reforms that are desirable, because they would consist in reconciling the accomplishment of an employer's duty and the greatest amount of initiative and liberty that can be left to employees taken individually.

When a company obliges its employees to insure in its fund, when it therefore substitutes its own wish for the wish of the employee, it seems to undertake in exchange a corresponding guarantee to give the employee all the advantages he might get from unfettered insurance. To the latter he cannot apply just because he is restricted to special insurance. And this is true even when the company itself makes allocations which serve to keep up the insurance fund, for obviously when we set aside a sum for the benefit of the employees, we ought to use it to the best advantage of the latter. At present, in some cases, when an employee asks for a personal book, he finds himself entangled automatically in a collective assurance and in almost all cases, — I am alluding at least to all European countries, — an employee who dies before the age required for a pension leaves to his widow a trifling sum not to say nothing at all, because in the countries comprised in Mr. Lemercier's report, there is no insurance upon life.

I should like to draw your attention to this point which is a failing, perhaps the most serious one, in our employers' organization. Can we succeed, without increasing the charges, for the charges that fall upon the companies on this account are already considerable, not by an augmentation, but by a different subdivision of the charges, to arrange for assuring life? I believe we could because I was much struck, you will be yourselves, by reading the documents contained in Mr. Riebenack's very weighty report.

In the United States, by combinations of exceedingly great elasticity and variety, with which are connected the institution of special savings banks and the formation of cooperative societies for buying shares, they succeed in letting an employee take advantage of all kinds of life assurance and of insurance generally. If an employee belongs to the Pennsylvania or to the relief-fund which is a common fund of a large number of companies, he can be assured directly in the company's fund and I was much impressed by hearing just now that the insured person can if he dies, by having 1 per cent stopped out of his wages, leave as much as 12,500 francs (£500) to his heirs. When, on the other hand, we turn to other companies, the arrangements are slightly different. They reach the following result : through outside companies, *i. e.* actual assurance companies, the employee can take advantage of all forms of insurance of whatever kind. The employee can have his choice of insurance, of beneficiaries and even, in most cases, the choice of the insurance society. They start with the idea that individual choice should have a large share in a question which may be put shortly as follows : the creation of a capital sum and the disposition of this portion of patrimony after death to the person for whom it was constituted.

Some companies have already on principle gone in this direction as far as they could. This is also the system followed by English law which leaves an employee free to choose between the company's rate or that of the administration to which he belongs or an open rate if he finds it more advantageous.

This is the system that seems likely to be adopted by the bill brought before the French Parliament and for which a day for discussion may yet be found.

This bill concerns workmen's pensions; it renders a pension obligatory — this is its principle — but it allows a workman who on principle ought to be insured by a payment made into a State fund, to refrain fròm paying money over to the State if he shows that he is insured in some mutual or other company.

I suggest then, that in reality the principles adopted both by the English law and by the French law, if it becomes law some day, and they would seem to be general principles, are the following : it is the duty of the employer to see that his employees are insured, but that his duty perhaps stops there, and his right too; and that in reality, he should leave to his employee the greatest amount of liberty possible, under the control of the companies, as to the form of the insurance. Reforms are desirable in this direction which shall permit of reconciling the accomplishment of the employer's duty with the utmost amount of initiative that can be left to the employees. If we start from this position, we can prove ourselves the benefactors, friends and counsellors of our employees, but as a matter of fact we are not their guardians.

Mr. John Pickering, South Australia Government Railways. — Mr. President, I feel that we are indebted to the reporters for the excellent reports we have heard. No reference has been made, however, to the provident institutions connected with the State railways in South Australia. I have prepared the necessary information in pamphlet form, and I will ask the President to be good enough to include in the Congress papers, if he can see his way clear to do it, this information that I have prepared (*vide* appendix II).

It seems to me that just as for the successful running of our trains attention must be paid to the less distinguished part of our railway equipment, so that smooth running may ensue, so the better the condition of the rank and file, the freedom from anxiety, so far as it can be done, with which they work, the better service they give; and this tends to the proper working of all concerned. During recent years, we learn by the report before us, that many of the railway managements of the world are moving in this direction, and if you will bear with me, I wish to place before you what the South Australian Railways are doing in this respect. Our railway employees, with the exception of shop and glut men, are compelled at the age of 21, or later when joining the permanent staff, to insure their lives in one of the societies approved by the government. They pay a premium according to their earnings, the rate of the earnings. The department collects the premiums each half year and pays over promptly to the society concerned; so that the employees have no trouble in paying their money, it is deducted on the pay roll; and the life insurance companies have no trouble in collecting, because the money is collected for them and paid in. We hold the policy in the department, as shown by the regulations in this pamphlet (*indicating*). I may say I have a few copies of this pamphlet, and if any of you care to see it I have a few for distribution at the close of the meeting. If the officer or employee prefers to join the Public Service Superannuation fund he may do so, instead of insuring his life. One of the advantages of the superannuation is this. If a man insures his life on an endowment principle, maturing at 60 years of age, he may fall sick when he is 40 years of age, and thus he is not able to earn any money while he is sick, incapacitated, and he still has to keep on paying his life insurance premiums. He has to keep paying them until he is sixty years of age, if he survives; but in the case of the superannuation fund, he receives a benefit at the time when he most needs it. If he has been a member five years he is then entitled to go on the fund, and if he is sick for a year he receives benefit, and during the time he is on the fund, he does not have to pay anything into the fund. This fund by an act of Parliament is open to all the civil service employees of the State — not only the railroad employees. I think I cannot do better than to read a few of the regulations governing this fund :

The fund is administered on a purely mutual principle by a board, three of whom are appointed by the government and four elected by the subscribers, the government assisting to the extent of guaranteeing the payment of annuities during the first fifteen years, of collecting the subscriptions each pay, and undertaking the clerical work.

So you see that the government has no control over this except that it nominates three members out of the seven. You notice that it guarantees the payment of annuities during the first fifteen years. As most of you know, there is no danger of the fund failing to pay the first fifteen years; as a matter of fact, it is after that where the difficulty comes in, when the older men come on the fund.

2° Subscriptions being deducted from the pay-sheets, under the act of Parliament, section 18, there are no commissions to be paid. The expenses will therefore be nominal and practically the whole amount of subscriptions and interest will be available in the shape of benefits for subscribers;

3° Subscriptions are distributed evenly over the year, a very small deduction of equal amount being made from each paysheet;

4° No payment of subscription whilst the subscriber is incapable of earning ordinary pay;

5° If the superannuation board be of opinion that incapacity for work, by reason of ill health or infirmity, will continue for a year, the subscriber will be entitled to an annuity for a year, and may at the end of the year apply for another year's annuity, and so on from year to year as long as, in the opinion of the board, the incapacity lasts;

6° When he retires at or after age 60 if in division A or at or after 65 if in division B of the fund, a subscriber will be entitled to an annuity for the remainder of his life;

7° Upon the death of a subscriber who has not less than five years' status, his widow will be entitled to an annuity for her life. The fact that the subscriber himself may have drawn an annuity on breakdown or in old age will not make any difference to the right of his widow to an annuity, provided they were married prior to his retirement;

8° If both parents die, and the father had a status of five years in the fund, his children will be entitled to an annuity until they reach 18 years of age.

The widow and the children get about two thirds of the employee's pension. You see a subscriber has to subscribe five years before he can get on the fund. But, if he prefers it, he can pay five years' subscription down in cash; or there is the five years' status which he can purchase by deferred payments extending over twenty years, he being charged 3 $^1/_2$ per cent interest and $^1/_2$ per cent assurance. That assurance means this, if you will allow me to explain. Some members will pay their payments for a period less than twenty years, some will fall out through death and so on, and we put $^1/_2$ per cent on to cover this. When a man has paid the first instalment of the twenty years' payment, he is then on the books for his pension whenever he is incapacitated.

Time is short this morning and I do not want to presume upon your patience too much, but I want to show you that a man under this fund after he has paid five years' subscription, either in cash or by the deferred payment system, is entitled the moment his health breaks down, the moment he cannot work any longer, to go on this fund, not as a matter of charity, but by virtue of his subscription; and provided he dies, his widow is provided for, and supposing she dies and there are young children, they are provided for until they can earn wages. It seems to me that that meets the larger difficulty, the larger requirements of a man's life; he knows that to some extent he is provided for. We allow the men to pay a subscription in accordance with their pay, not a percentage, but the men on the daily staff pay 4 or 5 or 6 or 7 or 8 pounds sterling, as they choose, per year; and if they wish to buy a five years' status on the deferred system, on the basis of a 4 pounds annual subscription, they would pay 4 shillings and 4 pence; or on the basis of 8 pounds, they would pay 8 shillings and 8 pence per fortnight. The £8 subscription in that case would give them at least 10 shillings a week pension for their life, and correspondingly for their widows or family. In the clerical staff, an employee pays from 8 to 16 pounds per annum, and that £16 would give at least a pension of £1 a week. There is an annual increment, the longer a man pays in, the greater his pension will be; but that annual increment has not been fixed yet. We have employed one of the best actuaries in Australia, who is formulating the whole fund. He says we can give these initial pensions, but the increment on the pensions he cannot state at present.

I may say that this fund has only been two years in existence. We have £24,000 in hand. We have very few pensions to pay, in all amounting only to a trifling sum, and nearly the whole of this is invested in government bonds bringing us in 4 per cent interest, and although the railroad men are not compelled to join this superannuation fund (many of them had insured their lives before it was started), yet many of them felt the advantage of it to such an extent that they contribute now one third of the annual income to the superannuation fund, though many of them are also paying their compulsory life insurance. So with an income of £12,000 a year to this fund the railroad men pay £4,000 of that.

We also have a provident fund which is voluntary, open to all grades of state civil service employees. A uniform levy is made on members when one of their number dies, the amount of such levy being determined by the sum to be raised, which varies from 75 to 100 pounds sterling, according to the age of the deceased member at the time he joined; such sum is handed over to the family or nominee.

The hospital fund provides treatment at hospitals free of cost to the voluntary subscribers. The department collects an annual levy of one quarter day's pay from members, and hands it over to the executive of the fund. The amount collected is divided among approved hospitals and according to the number of members who have been patients, a minimum payment of 15 shillings per week per patient being guaranteed.

Of course these items are quite apart from the private contributions that the members make in their own benefit societies and private individual life and insurance companies.

I may say that we have no Y. M. C. A. in connection with our railways as you have in America, although I think we should have.

The President. (In French.) — Has any one else any remarks to offer?

Mr. Lionel Marie, French Northern Railway. (In French.) — I gather from reading the papers and reports that have been sent us on the one hand, and from the discussion on the other hand, and from what I know of the subscriptions derived either from the companies or from the staff, that the sacrifices made voluntarily by the French companies are at least equivalent to all that has been done by other railway companies or other railway managements.

The President. (In French.) — In a question such as this, it is hard to formulate any definite conclusions.

We learn from the explanations we have heard, that the solutions adopted are very different, on the one hand, in the English-speaking countries, where the initiative is freely left to employees as to the insurance they may effect by applying most frequently to private companies with more or less extensive and more or less direct assistance from the railway companies, and on the other hand, in continental countries where special funds are organized by the companies, supported by payments, and in these the capital intended for paying pensions is accumulated.

In view of these divergent practices, it appears to me impossible to formulate any conclusion that gives the preference especially to one system or the other. I think therefore, we ought to restrict ourselves in our conclusions to general considerations, summarizing what appears to arise from the explanations that have been exchanged.

With this end in view, I have prepared a scheme of conclusions which are more a summary of the discussion than real conclusions. We have no real decision to arrive at. If you will allow me, I shall now read them to you.

" From the reports presented and the discussion at the meeting it appears :

" That in all European and American countries there exists, for the benefit of employees and their families, a great variety of philanthropic and provident institutions which the railroad companies have considered themselves morally obliged to create or to subsidize.

" As to insurance and retirement institutions, the Congress finds that, in a general way, measures are taken to organize or facilitate the insurance of employees against sickness, accidents, early incapacity, old age and death.

" For sickness the question is solved, in some countries, by legally obligatory insurance or by funds voluntarily established by the railroad companies or by the participation of employees in mutual insurance societies more or less subsidized by the management or by the direct help of the latter.

" As to accidents while at work, provision is generally made either by independent and voluntary insurance, or by legal provisions, or in some countries by compulsory insurance.

" It follows from the reports presented, that provision is made against incapacity due to age or against death, by insurance arrangements made with companies not connected with the railroads; by funds connected with the railroad, supplied by the contributions of the employees and the management, which funds are set apart for the carrying out of the insurance, or by other means.

" As to the latter funds, and as far as institutions are concerned which guarantee a fixed pension to the employees, or their families, by means of yearly contributions :

" The Congress finds, that in order to work properly, they should be organized on scientific insurance principles; but that while theoretically it may be possible to establish an absolute equality between the contributions to be made and the risks to be covered, in practice it is found that these risks are of too complicated and too varied a nature to attain with certainty the result desired.

" The maintenance of these institutions, where they exist, imposes on the companies considerable expense, which increases greatly when the age limit entitling to a pension is lowered.

" While consenting to a considerable expense, it is always to be apprehended that, in consequence of conditions which are impossible to foretell, such as the lowering of the rate of interest, etc., the expense may exceed the resources, thus giving rise to the necessity for revising periodically either the amount of the contributions, that of the pension, or the age of admission to the retirement allowance.

" According to the documents included in the reports, it is possible to avoid these difficulties and at the same time to leave more to the personal initiative of the employees by having recourse to arrangements based on contributions, made either to institutions, mutual insurance companies, or others, the proceeds of which can be arranged by each employee to guarantee such risks as best correspond with his individual circumstances. "

Mr. Th. Ronayne, New Zealand Government Railways. — Mr. President, I would respectfully draw your attention to the fact, before these conclusions are taken into consideration, that several members, several British delegates at least, have not had an opportunity of laying their views before the delegates.

The President. — Before we read these conclusions, it was asked whether any other members desired to submit any views.

Mr. Th. Ronayne. — In reply to that, I will say, with all respect, that I did not hear the invitation and neither did my colleagues who were sitting close by. I think the matter should be further considered.

Mr. Lewis Wood, Railway Clearing House, Great Britain. — Mr. President, I think if you will allow this clause to be added to the conclusions you have arrived at, it will meet all the requirements of the English speaking countries :

" That as superannuation funds are most desirable in the interest of both employers and employees, it be a recommendation of this Congress that such funds may be as far as possible made general, and in order to remove the difficulties that may arise in paying the pensions, they be guaranteed by the railroad, or by the governments where the railroads are state-owned, subject of course to the strict supervision of each and every fund. "

The President. (In French.) — I think what Mr. Wood proposes is too categorical to be regarded as the outcome of the section's discussion. The general view on the contrary has been that it would be well to leave employees free to choose between funds organized by the companies or, on the other hand, assurance funds independent of those founded by railway companies, as is usual in the United States.

I therefore think the addition demanded would not be in conformity with the opinions expressed by the majority of the section's members.

Mr. Hugh McLachlan, New South Wales Government Railways. — I beg to support Mr. Wood's resolution. It seems to me it is not at variance with the tenor of the conclusions proposed. It maintains, what should be the first principle in all life insurance, that is the solvency of the fund. That I think should be the first principle in any insurance fund, that there shall be some guarantee of solvency, and that is the object aimed at by Mr. Wood's resolution. Of course, so far as the State is concerned, I think we will be quite willing to follow what a private company would do. Personally, I think the resolution is a fair one because, as I say, it aims at the adoption of the first principle in regard to any insurance, and that is in regard to solvency.

Mr. Riché. (In French.) — We as the Congress are asked to decide that governments should intervene to give a guarantee and the Congress, which can only give general opinions, is requested to propose what is almost a political solution which concerns governments. I do not think we can agree to that.

On the other hand, as regards railway companies, it seems to me there is one unalterable principle, namely that the engagements entered into by railway companies or railway managements with their employees must be respected. It is not therefore possible to suggest any alterations in contracts which have been already made.

Mention was recently made of the Madrid & Saragossa Railway and others. I may allude to the American companies or the societies of the American railways which, jointly with their employees, have decided that they would only allot a certain sum to guarantee the pension fund or, like the Madrid & Saragossa Railway, decided that if the funds applicable were insufficient, it would be impossible to supplement them.

There are consequently individual contracts entered into between the men and the companies and we have no business either to alter them or sit in judgment upon them.

The proposal may be interesting from a moral point of view, but it is beyond the scope of the Congress.

Mr. Th. Ronayne. — With regard to the guarantee, I might state that in New Zealand we have a very excellent superannuation fund, and that it is guaranteed by the government; it worked admirably and the government has not been called upon to make good any deficiency. They realize that to attract men to the service and keep them in the service it is a desirable thing that the employee should have a certainty of getting his superannuation benefit, when it becomes due, and I think there should be no serious objection on the part of delegates agreeing to the guarantee.

Mr. R. H. Selbie, Metropolitan Railway, Great Britain. — I rise to support the resolution proposed by Mr. Wood as an addendum to the resolutions offered before, and I do not think myself it is in any way at variance with the conclusions which have been read by the President. It is not, as has been stated, so much a political matter as a matter for the various railroads themselves, and we as delegates for the railways I think can very properly discuss this question of guarantee. I have had experience in two superannuation societies myself, and in both of those cases the actuaries have sought to put restrictions on the benefits of the fund, which on ordinary insurance bases and along common sense lines are totally unnecessary. In the interest of both the employers and the employed, it is very desirable that the funds should be absolutely solvent, and that can be accomplished very easily by the companies themselves guaranteeing the superannuation funds for the benefit of their employees. I do not think there is anything in the addition to the conclusions which has been proposed that is at variance with the spirit of them and it would be a fair thing, I think, to include what is proposed by Mr. Wood.

The President. (In French.) — We might suggest in our conclusions that a certain number of our members recommend especially the system of superannuation funds. But it would be going too far and overstepping our bounds to recommend this system to the exclusion of any other, when we have learnt from our discussions that, especially in the United States, one of the most generally adopted solutions is for the employees to form mutual aid societies or other similar institutions very different from superannuation funds.

We might of course mention one of the systems brought to our notice as apparently worth recommending, but without that meaning to exclude others.

Mr. Lewis Wood. — I do not think the President, with all due respect, has followed the point of my resolution. At the clearing house, we have a superannuation fund which a the present time amounts in funds to £1,250,000. We have an income of £125,000. Our outgo is £50,000. Consequently that sum of a million and a quarter is added to every year by £75,000. Can you with any reason at all say that our fund is insolvent?

The actuaries say it is insolvent. We think it is absurd. That is the point, we want the company to take the whole of that money and never pay anything as they do now. They pretty well agreed to it and I think this would set it going. As I have said, I am a member of the clearing house of London and we have upwards of 15,000 members. We have a million and a quarter in funds. That produces £125,000, made up by its own interest and by our 2 $^1/_2$ per cent paid by ourselves and by a similar amount from the company. Our outgoings are £50,000. Consequently we are saving £75,000. That goes to the fund of one million and a quarter. And yet they say we are deficient.

The President. — It may be.

Mr. Lewis Wood. — They say it is insolvent and according to their balance shut it would appear to be so, but the fact is they have in valuing it treated it as a terminable fund instead of an " ever-going concern ".

The President. (In French.) — If actuaries have said so, it may be correct.

I say again that we should be overstepping our bounds if we advise a government to start a fund. We can state that some members think that the companies ought to step in and guarantee the amount of the funds, but our discussion cannot bind companies to give such a guarantee.

Mr. Marcel Lemercier, *reporter*. (In French.) — We have seen that there are many funds which may find themselves insolvent. Mr. Wood tells us that the Clearing-House fund is in that position; it is an unfortunate thing, but I have indicated in my report that for funds that are insolvent, there are two main solutions, either transformation or liquidation. There is no reason for starting a guarantee which most of the companies would refuse to do because it is not included in the bye-laws of their funds and which some States might likewise refuse to do, because we are not entitled to force any obligation upon them. We are not an international Parliament; we are only a Congress.

Mr. Lewis Wood. — Granted, but as this motion has been proposed and seconded, I ask that it be put to the meeting.

The President. (In French.) — Will those in favour of the motion kindly signify the same by holding up their hands.

— The motion was negatived.

The President. (In French.) — If there is no other objection, the conclusions as submitted are adopted.

We have now got through our last subject and consequently the labours of the section are terminated.

It only remains for me, gentlemen, to thank you for the help you have afforded me towards successfully carrying out our task.

— The meeting then adjourned.

DISCUSSION AT THE GENERAL MEETING

Meeting held on May 13, 1905 (afternoon).

MR. STUYVESANT FISH, PRESIDENT, IN THE CHAIR.

GENERAL SECRETARY : MR. L. WEISSENBRUCH.

ASSOCIATE GENERAL SECRETARY : MR. W. F. ALLEN.

The President read the

Report of the 4th section.

(See the *Daily Journal of the session*, No. 9, p. 191.)

" Two very full and interesting reports were presented by Mr. M. RIEBENACK and by Mr. Marcel LEMERCIER.

" The reporters have not limited their investigation to the question announced in the heading : " General principles of plans for the retirement and insurance of railway employees and workmen. "

" They have extended their inquiry to all provident institutions established by railroads to improve the material and moral well being of the employees.

" As to insurance, the English speaking countries leave much to individual initiative. Mr. M. Riebenack describes in his report and in a supplement, filed with the section, all such organizations found in America — life and accident insurance, mutual insurance, endowment insurance, railway relief departments, employees' relief associations.

" Life and accident insurance are contracted for with insurance companies, managed independently of the railroad companies, which agree to issue insurance policies suitable to the different conditions. A policy is given to each employee. Certain administrations have organized for themselves a system of accident insurance on bases similar to those of the accident insurance companies. Mutual benefit or relief insurance is similarly organized ; they form only a particular case of the first class.

" Endowment insurance, or insurance by donation, is quite different. It has its origin in a donation, the annual interest of which goes to a fund, from which allowances are made to sick or infirm employees or those injured by accident or in case of death to their families.

" Railway relief departments are organized and managed by the companies with the cooperation of the employees. They act in case of sickness or accident, and also in case of death. Nine American companies, having a total mileage of 31,000 miles and 320,000 employees, two-thirds of which are members, maintain such departments; the annual expense for the whole is about $2,200,000. Employees' relief associations form, as a rule, small organizations exclusively among the employees and managed entirely by them; the companies do not interfere, except sometimes to subsidize them.

" On the railroads of Great Britain, organizations exist similar to those enumerated above for America. Independent of all these insurance combinations, there exist in the United States pension or retirement funds organized by the companies, which provide a fund for employees of all classes, to be used for pensioning them when retiring from service at the age of 65 or 70 years. No deduction is made from the salary of the employees.

" Replying to a question by the PRESIDENT, Mr. M. RIEBENACK added that the Pennsylvania Railroad has decided, in order to insure the operation of the retirement pensions, to make a yearly appropriation, which may reach the maximum of $390,000, which sum is a part of the annual budget. This sum has, in fact, been always more than was required to cover the yearly amount of these pensions. The pension is computed on the average salary for the last ten years of service, with variable premiums according to the length of the service,

" In England, there also exist retirement funds, which differ from the preceding in that the employees entitled to the fund must contribute to its maintenance. The age limits for retirement are lower than in America.

" Mr. M. Riebenack also reported on a special institution of the Pennsylvania Railroad. This is a fund for the aged (relief fund), maintained by the employees by the payment of 1 per cent of their salaries, which is used to supplement their pensions.

" Similar funds exist in England, where they are in force through legal enactments (general power acts). The resources consist in payments by the participants, generally fixed at 2 per cent of their salaries and in payments of equal amounts by the companies.

" Mr. M. Riebenack finally described the great development of all kinds of paternal institutions — saving funds, medical services and hospitals, loan institutions, libraries and reading rooms, literary institutes, Young Men's Christian Associations, dining rooms, restaurants, fraternal associations, etc.

" For other than the English speaking countries, the reporter, Mr. Marcel

Lemercier, enumerated all fraternal institutions in existence under different systems examined by him — free lodging with heating and lighting, allowances for lodging, stores and cooperative supply societies, workingmen's houses, dining rooms, schools, travelling facilities, subsidies to certain hospitals, sanitoriums, etc.

" He then described legislation on accidents while at work. In some countries, legislation is based on the principle of compulsory insurance; in others, the working of indemnities or pensions to the victims of accidents is assured, either by voluntary insurance combinations or by the railroads.

" Mr. Marcel Lemercier then took up the question of retirement funds, which are much developed in the countries studied by him; these funds are either public or created by the companies. In France, these funds are maintained to a great extent by the contributions of the companies, and they insure a pension in proportion to the average salary of the last years of service, with a reversion to the widow and children. The pension is supplemented when the years of service exceed a certain limit or in case of accident.

" Returning, then, to the question proper, as formulated on the programme of the Congress, Mr. Marcel Lemercier considered, from a scientific point of view, the principles which should govern an ideal pension fund.

" The risk to be covered is the product of four factors : the amount insured, the probability and amount of the loss and the time for which the insurance is in force. It is the present value of the possible loss; on the other hand, the amount assured depends on the average pay. The probability and, therefore, the amount of the loss can only be determined in advance by general averages. To the tables of sickness, accidents and mortality it is, therefore, necessary to add, in the case of retirement of railway employees, tables of elimination, including all forms of retirement, for the risk to be covered is in the nature of a disappearance of the employee's pay, whatever the cause may be.

" Taking into account all the factors of the risk, especially the age at which the insured enjoys the benefit, the system of premiums, intended to constitute the reserve fund, should be determined by scientific methods.

" After laying down these scientific principles, the reporter pointed out the practical difficulties of obtaining the equivalence between the payments to be made and the risks to be covered, these risks being of a complex and varied nature. To proceed correctly, it would be necessary to establish mathematical reserves representing the value of the obligations of the insurer, and to check these reserve funds by means of periodical balance sheets.

" It is a fact that, in the long run, a deficit may arise in the retirement funds. What measures should then be taken? Mr. Marcel Lemercier suggested two efficient solutions : the first consists in liquidating the funds and covering the deficit found, so as to prevent the absorption of the capital; the second is the reorganization of the fund, and in this connection, the reporter suggested, as one of the most efficient means, raising the age at which the insured benefits from the pension.

" It appeared from the abstract of the two preceding reports, that pension institutions are divided into two great systems. While on the continent of Europe retirement pensions are secured by funds established by the companies, where the capital proceeding from endowment by the latter, and from payments made by employees, accumulates, it is found in America and England that the system of individual initiative predominates in all its forms.

" Mr. Riché (*French Eastern Railway*) explained all the advantages which this system of personal liberty presents, when considering the subject from a higher point of view. It was his opinion that it is the duty of the employer to see that his employees are insured, but his duty stops there, and he should grant the utmost liberty in the matter of choice of the form of assurance. The duty of the employer can be perfectly reconciled with the allowance of the greatest individual liberty to the employees.

" After data had been furnished by Mr. John Pickering (*South Australia Government Railways*) on the organization of compulsory insurance and provident institutions in Australia, the discussion was closed.

" The President stated the impossibility of framing any conclusions on the subject of pensions, or of recommending any particular system, to the exclusion of all others, and he expressed the opinion that it was advisable merely to put on record the information gathered regarding the different systems presented, and to state their peculiar features.

" The form of resolution which he presented to the section from this standpoint, led to some observations on the part of Mr. Thomas Ronayne (*New Zealand Government Railways*), Mr. Lewis Wood (*Railway Clearing House, England*) and Mr. R. H. Selbie (*Metropolitan Railway, England*), who requested an amendment intended to generalize the institution of pension funds and have their revenues guaranteed by the managements interested, companies or States.

" To the majority of the section, this proposition did not appear to cover the subject as defined by the president and it was not adopted.

" Consequently the 4th section adopted a form of resolution worded as follows. "

The President. — The following are the

CONCLUSIONS.

" From the reports presented and the discussion at the sectional meeting it appears :

" That in all European and American countries there exists, for the benefit of " employees and their families, a great variety of philanthropic and provident

" institutions which the railroad companies have considered themselves morally obliged to create or to subsidize.

" As to insurance and retirement institutions, the Congress finds that, in a general way, measures are taken to organize or facilitate the insurance of employees against sickness, accidents, early incapacity, old age and death.

" For sickness, the question is solved, in some countries, by legally obligatory insurance or by funds voluntarily established by the railroad companies, or by the participation of employees in mutual insurance societies more or less subsidized by the management or by the direct help of the latter.

" As to accidents while at work, provision is generally made either by independent and voluntary insurance, or by legal provisions, or in some countries by compulsory insurance.

" It follows from the reports presented, that provision is made against incapacity due to age or against death, by insurance arrangements made with companies not connected with the railroads; by funds connected with the railroad, supplied by the contributions of the employees and the management, which funds are set apart for the carrying out of the insurance, or by other means.

" As to the latter funds, and as far as institutions are concerned which guarantee a fixed pension to the employees, or their families, by means of yearly contributions :

" The Congress finds, that in order to work properly, they should be organized on scientific insurance principles, but that while, theoretically, it may be possible to establish an absolute equality between the contributions to be made and the risks to be covered, in practice it is found that these risks are of too complicated and too varied a nature to attain with certainty the result desired.

" The maintenance of these institutions, where they exist, imposes on the companies considerable expense, which increases greatly when the age limit entitling to a pension is lowered.

" While consenting to a considerable expense, it is always to be apprehended that, in consequence of conditions which are impossible to foretell, such as the lowering of the rate of interest, etc., the expense may exceed the resources, thus giving rise to the necessity for revising periodically either the amount of the contributions, that of the pension, or the age of admission to the retirement allowance.

" According to the documents included in the reports, it is possible to avoid these difficulties and at the same time to leave more to the personal initiative [and liberty of action] (1) of the employees by having recourse to arrangements based on contributions, made either to institutions, mutual insurance companies, or

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(1) The words enclosed in brackets were added by the general meeting. (*See* discussion hereafter.)

" others, the proceeds of which can be arranged by each employee to guarantee " such risks as best correspond with his individual circumstances. "

The President. — Has no one any objection to raise?

Mr. Guerreiro, Ministry of public works, commerce and industry, Portugal. (In French.) — I propose we add to the last paragraph after, the words " leave more to the personal initiative ", the words " and liberty of action ".

Mr. Emile Heurteau, *president of the 4th section.* (In French.) — That expresses the views taken by the section. There can be no objection to the suggestion.

Mr. L. Weissenbruch, *general secretary.* (In French.) — The wording would than run as follows :

" According to the documents included in the reports, it is possible to avoid these difficulties and at the same time to leave more to the personal initiative *and liberty of action* of the employees by having recourse to arrangements based on contributions, made either to institutions, mutual insurance companies, or others, the proceeds of which can be arranged by each employee to guarantee such risks as best correspond with his individual circumstances. "

The President. — Does any one object to the conclusions as amended?
If no one protests, they are adopted.

APPENDICES

[385 .517]

APPENDIX I.

2nd supplement to report No. 1,

By M. RIEBENACK,

COMPTROLLER, PENNSYLVANIA RAILROAD.

There were received by last week's mail from Africa the regular replies of the "Natal Government Railways" to printed lists of reportorial questions on the above-mentioned subject sent out under date of January 14th last. The railways, through their assistant general manager, Mr. J. M. Hunter, explain the cause of and express regret for the delay in transmitting responses, with the statement that it grew out of the fact that some of the printed lists were mislaid, thus precluding earlier attention. I realize that this is a late date for submission of data for incorporation in reports, but in view of the attendant circumstances as above recited, as well as the distance involved, it is considered the information should be offered to the Commission for such treatment as may be deemed proper, and at the same time, as an incidental consequence, place the respondents on record as active participants in congressional investigation on this particular subject, and enable the fullest possible discharge of my assignment.

These replies, like those for the National Lines of Mexico, sent you under date of the 5th instant, should properly be located, under appropriate headings, in the Supplemental Report of October 22, 1904. As for the Mexican road just named, I have pleasure in giving below a form of report for the African railways, which will, it is thought, largely facilitate arrangement and use of the matter for publication purposes :

A. — *Insurance and relief provision.*

This subject is discussed on pages 163, 175 and 177 of Supplemental Report, and the following report should follow discussion under heading "Great Britain", page 175 :

AFRICA.

Natal Government Railways.

(679 miles; 4,835 employes, Europeans.)

Inauguration. Apart from relief extended by the government, consisting of full pay in case of accident and half-pay in sickness, there is conducted an organization styled the "Natal Government Railways Mutual Benefit Society", established in March, 1885.

Objects. Objects are : administration of pecuniary relief to members in case of sickness or accident, and to provide a sum of money, in name of funeral expenses, which is paid to proper representatives of deceased member.

Membership quirements.

Membership is voluntary, and includes any officer or servant of the Natal Government Railways Department, over 14 and under 45 years of age (Indians and Natives excepted) who may make application and pass satisfactorily physical examination by society medical officer.

ontributions nd benefits.

Members are entitled to benefits in three months according to following scale :

CLASS.	Entrance fee.	Weekly contributions.	Per day when sick.	At death.
1	6*s*.	1*s*.	4*s*. 0*d*.	£20
2	4*s*.	9*d*.	2*s*. 8*d*.	15
3	2*s*.	6*d*.	1*s*. 4*d*.	10
1s. a month extra for medical attendance and medicines if wife is on the doctor's list.				

ontinuance sick benefits.

Where disability exceeds period of sixteen weeks, committee of management is empowered to grant two-thirds of scale allowance for further period not exceeding sixteen weeks; and where disability continues beyond latter period, committee may grant one-third of scale allowance for additional period not exceeding sixteen weeks; any further allowance in exceptional cases being entirely dependent upon state of the funds, and subject to discretion of the committee.

Financing.

Society is financed by government grants (grant for the year ended March, 1903, having been £500), and contributions of members.

Leaving he service.

Where member has paid contributions continuously for twelve months and leaves service of Railways Department, he receives back a sum equivalent to 25 per cent of his total contributions after deduction of all sums which may have been paid to or for him.

Deficits.

Where deficiencies in funds are found, the committee is empowered to levy from members such sums as may be required to meet the emergency.

Receipts.

Income for year ended March, 1903, £2,203.15*s*. 6*d*.

xpenditure.

Expenditure for year ended March, 1903, £1,931.0*s*. 6*d*.

Total expenditure during the eighteen years of society's existence to and including March, 1903, £16,659.

Number members.

Membership as of March, 1903 : 710.

C. — *Superannuation provision.*

This subject is discussed at page 197 of Supplemental Report, and following report should appear immediately after discussion under heading " Great Britain " on said page :

AFRICA.

Natal Government Railways.

(679 miles; 1,835 employes, Europeans.)

Inauguration. The present organization is styled the "Natal Government Public Employees' Superannuation Fund", framed under act No. 29, 1897, and effective January 1, 1898, which embraces all persons in the public employ not entitled to pension or retiring allowance under any other law, act, or scheme. Up to December 31, 1897, there had been in operation the incorporated "Natal Government Railways Superannuation Fund", effective as of January 1, 1885, and which embraced the following employees :

a) Principal officers of the department and clerks and other European officials attached to their offices;

b) Station masters, clerks and checkers;

c) Inspectors, foremen.

The railways, fund was incorporated, without prejudice to its members, with the wider government scheme under said act No. 29, 1897.

Admission age. Maximum age for entrance to fund, 40 years.

Financing. Fund is financed by a percentage deduction from salaries and wages of contributors (amounting to two and one-half [2 $^1/_2$] per centum of actual salaries), and an equal sum paid by the government in each half-year. Only other source of revenue is the interest accruing from investments.

Retirement. Voluntary retirement at age 60 years and over, with ten years' membership, entitles to life allowance or annuity, by way of superannuation, in accordance with prescribed scale of allowances, computed on the average of the salary upon which contribution was made, the minimum and maximum yearly allowances being respectively, for ten years' membership, £25, and for 45 years' membership and upwards, £67, allowances for intervening ages being in proportion based on ascending scale.

Age 60 years, as above mentioned, may be reduced by the minister by not more than five (5) years, whenever circumstances of the case may warrant special consideration.

Other fund provision, by way of allowance, corresponds closely with the practice obtaining with like funds conducted by English railways.

Retiring age. Average age of retirement on allowance : 55 years.

Expenditure. Total expenditure since organization : £22,175.14*s*.

Number members. Number of contributing members : 950.

Beneficiaries. Number of beneficiaries being carried : 22.

Deaths. Number of deaths since organization : 26.

D. — *Hospital service.*

This subject is exploited at page 200 of Supplemental Report, and following report should appear directly after discussion under heading "Great Britain" on said page :

AFRICA.

Natal Government Railways

(679 miles; 4,835 employes, Europeans.)

General.

There are several hospitals connected with the railways, but these are provided for Indian laborers (a condition to their indenture).

There are no hospitals provided for the European staff, although at three important centres, special terms are allowed to members of the railway staff using the public hospitals. For instance, at the Government hospital, Durban, railway employees are charged half rates; likewise at Greay's hospital, Maritzburg; at the Ladysmith sanatorium, no reduction is made in the rates, but the railway department shares the expenses with the patients

E. — *Savings funds.*

This subject is treated at page 202 of Supplemental Report, and following report should appear directly after discussion under heading "Great Britain" on said page :

AFRICA.

Natal Government Railways.

(679 miles; 4,835 employes, Europeans.)

overnment
ivings Bank.

The Natal Government Savings Bank is the only institution of the kind in the colony. The railway department gives every facility to the employees to make use of the bank, by deducting any amounts desired from the pay-bills, and then forwarding same to the bank authorities, by whom all the accounts are kept, and who forward the deposit book back direct to the depositor. The railway department never sees the depositor's bank book, it being sent direct to the bank, and returned by that institution in like manner.

epositaries.

Deposits are received at the office of the controller of the Savings Bank, Pietermaritzburg, and at the offices of designated magistrates situated in various parts of the colony.

Amount
of deposits.

No deposit of less than 2*s*. will be accepted, nor will more than £25 be received on any one day. Only one deposit will be received on any one day.

epayment.

Where repayment is desired, application therefor is made to controller of the Savings Bank, or at any branch office, on special form, the pass-book being produced at same time.

Immediate repayment of any sum not exceeding £20 may be had in Maritzburg on payment of a fee of 1*s*.

Authority for repayment of any sum not exceeding £20 may be procured by telegraph at a charge of 2*s*., to cover cost of telegram to the head office, and the reply thereto.

Interest.

Interest payable to depositors is at the rate of £3.15*s*. per centum per annum, or such other rate as may be from time to time decided upon by the governor in council, on every complete pound deposited, and is computed from the first day of the calendar month next following the day on which a complete pound shall have been deposited, or on which deposits of a less amount shall have made up a complete pound up to first day of calendar month in which moneys are withdrawn.

Yearly addition of interest. Pass-books must be forwarded to the controller of the Savings Bank, Maritzburg, once in each year on the anniversary day on which the account was opened, in order that they may be compared with the books of the department, and the interest due to the previous 30th June inserted.

I. — *Literary institutes.*

This subject is treated at page 212 of Supplemental Report, and following report should appear directly after discussion under heading " Great Britain " on said page :

AFRICA.

Natal Government Railways.

(679 miles; 4,835 employes, Europeans.)

Inauguration. Identified with the Natal Government Railways' Institute, established in 1885, membership in which is open to all officers and servants of the Natal Government Railways.

Library. On June 30, 1903, the library contained 7,082 books, which had a circulation of 12,975 volumes during the year. The list includes art, science, biography, theology and philosophy, poetry, travel, fiction, essays, history, etc.

Magazines and papers to the number of 3,812 were also issued during the year.

Reading room. The reading-room is supplied with weekly and monthly magazines and journals.

Education. Classes are held during winter evenings for instruction in machine and building construction, geometry, and freehand and model drawing, and are open to all youths and apprentices in the Railway Harbor Works and Public Works service, also to the sons of any employee in the Government service.

Financing. The institution is supported by membership subscriptions and government grants, the subscriptions for the year ended June 30, 1903, having amounted to £150.0*s*. 6*d*., and the government grant to £300.

Receipts. Receipts from all sources during year ended June 30, 1903, amounted to £489.13*s*. 3*d*.

Expenditure. Expenditure, in all directions, during the year named, amounted to £485.6*s*. 10*d*.

Contributions. Members contribute monthly at following rates : seniors, 1*s*., and juniors, 6*d*.

Number members. Membership for the year named : 360.

Philadelphia, December 21, 1904.

[385 517 (.942)] APPENDIX II.

Note on the provident institutions of the South Australian State Railways,

By John PICKERING,

COMPTROLLER OF ACCOUNTS OF THESE RAILWAYS.

Provident institutions.

1° Life Assurance, started in 1889;
2° Public Service Provident Fund, started in 1893;
3° South Australian Railways Hospital Fund, started in 1902;
4° Public Service Superannuation Fund, started in 1903.

Life assurance.

The object is to secure a provision upon retirement at age 60 for the employee, or for his family in the event of his premature death.

By regulation of January 1, 1889, all who thereafter attained the age of 21, and new entrants — with the exception of engine-cleaners, greasers, pumpers, coalmen, mechanics, shop laborers, and a few others — have been required to assure in one of the approved societies, the latter being informed each month of those employees required to assure, and simultaneously a form is handed to the employee concerned. This form contains a recommendation by the district officer, a declaration by the employee as to his date of birth and the society chosen, the certificate of the comptroller of accounts that insurance is complete, and the approval of the commissioner for the permanent appointment. Upon acceptance of the proponent by the society, the premiums are thereafter collected half-yearly by the department and handed over.

Regulation No. 3.

The South Australian Railway commissioners, in pursuance of the powers conferred by the "South Australian Railway Commissioners Act, 1887," do hereby make the following regulation, and all previous regulations and by-laws conflicting herewith are hereby repealed :

Scale of insurance. — Every person before confirmation of his appointment to any permanent office or employment in the railway service, shall effect in some life insurance office, carrying on business in South Australia and approved by the commissioners, an insurance on his life, providing for the payment of a sum of money at his death should it occur before the age of retirement from the railway service, or, if he survives until that age, of a sum of money or annuity on the date of such retirement, upon the following scale, that is to say :

The amount payable at death or retirement shall not be less than the amount of the annual salary or wages of the insured. The amount of any annuity shall be such as the premiums payable upon that basis will purchase. Every such insurance or annuity shall be proportionately increased with every additional £50 received as yearly salary or wages.

Regulation No. 7.

The amount of insurance referred to in Regulation No. 3 shall be computed as follows :

SALARY OR WAGES PER ANNUM EXCLUSIVE OF OVERTIME.	AMOUNT OF INSURANCE.
Not exceeding £110	£100
Exceeding £110 and not exceeding £200	200
— 200 — — 300	300
— 300 — — 400	400
— 400 — — 500	500
— 500 — — 600	600
— 600 — — 700	700
— 700 — — 800	800
— 800 — — 900	900
— 900 — — 1,000	1,000

All insurances shall be at the rates for endowment insurance at 60 years of age, or for annuity according to tables of the insurance companies, which shall be signed by the accredited officer of the board of management. The premiums shall be payable half-yearly in advance, portions of a half-year being calculated *pro rata*, but the first premium payable to any company shall not be for a term of less than one full quarter.

The contract once entered into with a company shall not be varied, but all succeeding increases are to be made with the same company, without further examination, at the rates agreed on at the original contract, increased *pro rata* according to the age of the assured at the time of increased insurance. Should the occupation of any employee be varied after the date of the original contract, involving special risk, it shall be permitted to the company in which his insurance is effected to charge, in addition to the premiums, any special rate which, under the rules of such office, are ordinarily chargeable therefor. The employee shall, as a condition precedent to the confirmation of his promotion, lodge such additional policy as herein required. All policies shall be in the names of the assured, shall be lodged with the South Australian Railway commissioners, shall remain in their possession, and shall be unassignable either at law or in equity, provided that the amount so insured shall be payable to the employee on his leaving the service at 60 years of age, or to his legal representatives within three months after his death, should he die before attaining the age of 60.

No company shall be required to insure the life of any officer or servant for a larger sum than is provided by these regulations; but any additional insurance shall be a matter of contract between the assurer and the assured, and the policies in such cases shall not be lodged with the said commissioners, or be in anywise subject to these regulations.

A record of all insurances made in pursuance of these regulations shall be kept by the comptroller of railway accounts, and shall show the date and amount of the original insurance, and of each successive increase; and it shall be the duty of the said comptroller to arrange for deducting from the salary or wages of the assured, in accordance with Regulation No. 3, the premiums due to the insurance company concerned to the end of each calendar half-year, every 30th June and 31st December, and to pay the same to the said company. It shall be a condition of all policies, that in case of omission by the said comptroller to pay the said premium, the policy of the insurance shall not lapse till the expiration of one month after service of notice of such omission of the comptroller, and the company will within such month receive, if so required to do, such overdue premium without interest or fine.

Any employee, on resigning, being dismissed, or otherwise leaving the service of the said commissioners, shall have all policies in his name delivered to him, and the said commissioners shall not thereafter have any charge of the policies or liability in respect of the half-yearly premiums, and the said policies shall thereafter cease to be subject to these regulations, but the said comptroller of accounts will give notice to the insurance company interested, and the policies shall not be otherwise affected as a contract between the insurer and the insured so long as the premiums thereon are paid by the insured.

The public service superannuation fund.

This purely mutual fund is administered by a board, three of whom are appointed by the government and four elected by the subscrivers. The act gives a state guarantee for the payment of annuities during the first fifteen years of the fund's existence, and provides for the collection of the subscriptions each pay by deductions from the pay-sheets.

The following are some of the salient features of the Public Service Superannuation Fund :

1° The fund is purely *mutual*. Nobody else will share with the subscribers in the benefits which their subscriptions and the accruing interest will provide;

2° Subscriptions being deducted from the paysheets, under the act of Parliament (section 18), there are *no commissions* to be paid for collecting them;

3° Subscriptions are distributed *evenly over the year*, a very small deduction of equal amount being made from each paysheet;

4° *No payment* of subscription whilst the subscriber is incapable of earning ordinary pay;

5° If the Superannuation Board be of opinion that incapacity for work, by reason of ill-health or infirmity, will continue for a year, the subscriber will be entitled to *an annuity for a year*, and may at the end of the year apply for another years' annuity, and so on from year to year as long as, in the opinion of the Board, the incapacity lasts;

6° When he retires at or after age 60 if in division A, or at or after 65 if in division B, of the fund, a subscriber will be entitled to an *annuity for the remainder of his life*;

7° Upon the death of a subscriber who has not less than five years' status, his *widow* will be entitled to *an annuity for her life*. The fact that the subscriber himself may have drawn an annuity on breakdown or in old age, will not make any difference to the right of his widow to an annuity, provided they were married prior to his retirement;

PREMIUMS PAYABLE TO APPROVED LIFE ASSURANCE SOCIETIES.

For each £100 of policy. — Half-yearly premiums.

Age next birthday.	*Australian Mutual Provident Society.*			*Australasian Temperance and General Mutual Life Assurance Society.*			*Australian Widows' Fund Life Assurance Society, Limited.*			*Colonial Mutual Life Assurance Society, Limited* (1).			*Citizens' Life Assurance Company, Limited.*			*Equitable Life Assurance Society of the United States.*			*Mutual Life Insurance Company of New York.*			*National Mutual Life Association of Australasia, Limited.*			*New York Life Insurance Company.*			Age next birthday.
	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	
21	1	5	4	1	5	0	1	4	8	1	4	10	1	4	8	1	6	4	1	5	11	1	2	11	1	6	5	21
22	1	6	1	1	5	6	1	5	4	1	5	8	1	5	6	1	7	1	1	6	9	1	3	8	1	7	2	22
23	1	6	10	1	6	6	1	6	1	1	6	6	1	6	4	1	8	0	1	7	7	1	4	5	1	8	0	23
24	1	7	9	1	7	0	1	6	11	1	7	3	1	7	3	1	8	11	1	8	5	1	5	4	1	8	10	24
25	1	8	8	1	8	0	1	7	9	1	8	1	1	8	2	1	9	10	1	9	5	1	6	3	1	9	10	25
26	1	9	7	1	9	0	1	8	9	1	8	11	1	9	2	1	10	10	1	10	5	1	7	3	1	10	10	26
27	1	10	8	1	10	0	1	9	9	1	9	10	1	10	3	1	11	11	1	11	6	1	8	4	1	12	0	27
28	1	11	9	1	11	0	1	10	9	1	10	10	1	11	4	1	13	1	1	12	7	1	9	5	1	13	0	28
29	1	12	10	1	12	6	1	11	11	1	12	0	1	12	6	1	14	4	1	13	10	1	10	7	1	14	5	29
30	1	14	0	1	13	6	1	13	2	1	13	2	1	13	9	1	15	8	1	15	2	1	11	9	1	15	7	30
31	1	15	4	1	15	0	1	14	5	1	14	7	1	15	2	1	17	1	1	16	7	1	13	1	1	17	0	31
32	1	16	8	1	16	6	1	15	9	1	15	11	1	16	7	1	18	7	1	18	1	1	14	6	1	18	7	32
33	1	18	3	1	18	0	1	17	3	1	17	6	1	18	1	2	0	3	1	19	9	1	16	0	2	0	2	33
34	1	19	10	1	19	6	1	18	9	1	19	1	1	19	9	2	2	0	2	1	6	1	17	8	2	2	0	34
35	2	1	7	2	1	0	2	0	6	2	0	11	2	1	7	2	4	0	2	3	6	1	19	5	2	4	0	35

(1) 10*s.* per centum is added to these rates in the cases of guards, locomotive enginemen, and firemen.

8° If both parents die, and the father had a status of five years in the fund, his *children* will be entitled to *an annuity until they reach* 18 years of age;

9° If, before he acquires five years' status on the fund, a subscriber, through resignation or dismissal from the service, or by death, ceases to be a subscriber, the *full amount of his subscriptions will be repaid* out of the fund; and if he has purchased status for cash, the cash also will be refunded to him, and if he has purchased status by instalments, the instalments actually paid will be refunded, less the amount required to satisfy interest and cover the risk of non-payment;

10° If, after having acquired five years' status, a subscriber in good health retires from the service to better himself, or is dismissed, he will be *repaid the full amount of subscriptions* paid, and if he has purchased status for cash, the cash will also be refunded to him, and if he has purchased status by instalments, the instalments actually paid will be refunded, less the amount required to satisfy interest and cover the risk of non-payment, but if the subscriber is not in good health, the amount, if any, to be refunded will be entirely in the discretion of the Board;

11° Railway Regulation No. 14 requires the purchase of five years' status, so that the subscriber may be eligible for benefits forthwith. The price of this status may be paid in cash in a lump sum, or *payment may be spread over twenty years* or less, by instalments deducted from the pay-sheet with the subscription, the instalments being computed to cover interest and risk of non-payment as well as the purchase-money itself;

The status is effective immediately after the payment of the first instalment : *i. e.*, the subscriber is entitled to immediate benefits in case of breakdown of health, no matter how soon this may occur, or if he should die, the widow would receive her annuity;

12° A railway probationer may, prior to any departmental requirements, become a subscriber to the fund, and may either purchase status at once, or *defer* doing so until required by the department on the confirmation of his appointment, when he will be required to purchase *so much status only* as will make up the five years.

13° That all annuities are *absolutely protected* against creditors and cannot be mortgaged;

14° The Railway Commissioner's Regulation No. 14 provides the option of any railway employee to enter the Superannuation Fund instead of life assurance, and of subscribing to this fund instead of continuing compulsory life assurance;

15° Employees in good health may subscribe up to 8 per cent of annual pay, but not exceed £40 subscription per annum;

16° Subscribers over 32 must purchase status back to age 27, in accordance with Regulation 61 of the fund;

17° The price for status for all ages up to 43 next birthday is back subscriptions if paid for in cash; if paid by instalments spread over twenty years, the fortnightly or monthly deduction will be in accordance with the tables given below up to age 32, but if the age exceeds 32 next birthday, application should be made by letter to the executive officer of the fund, the treasury, Adelaide, for information as to the amount of the deduction;

18° A railway employee electing to join the Superannuation Fund, in lieu of insuring, is required to increase his subscription in proportion to increases in his pay up to age 32. After age 32, no further increase of subscription is compulsory.

The public service provident fund.

This is voluntary and unofficial, open to all grades of the State Civil service. A uniform levy is made on members when one of their number dies, the amount of such levy being deter-

FOR PROBATIONERS.

Division A. — For employees at daily rates, with option of retiring at 60 years of age.

SUBSCRIPTIONS AND ANNUITIES.

WAGES RECEIVED PER DAY.	Total fortnightly deduction from pay-sheet for subscription and purchase at any age up to 32 next birthday of five years' status by instalments spread over 20 years.	Reduced fortnightly deduction for subscription only after status has been paid for.	ANNUITY TO EMPLOYEE.		Widow's annuity continued after her death until the youngest child is 18 years old.
			In the event of incapacity for work, with a status of five years.	Amount by which the annuity will be increased for each year of status in excess of five acquired at date of incapacity, or at date of retirement at, or after age 60.	
s. *d.*	*s.* *d.*	*s.* *d.*	£ *s.* *d.*	*s.* *d.*	£ *s.* *d.*
Under 8 0	4 4	3 1	13 0 0[†]	4 0[*]	7 10 0
— 10 0	5 5	3 11	16 5 0	5 0[*]	9 7 6
— 11 6	6 6	4 8	19 10 0	6 0[*]	11 5 0
— 13 0	7 7	5 5	22 15 0	7 0[*]	13 2 6
— 14 6	8 8	6 2	26 0 0	8 0[*]	15 0 0

[†] This is equal to 5 per cent on £260.

[*] This amount as fixed *for the present*, more particularly affects foundation subscribers of 40 years and upwards of age, who in the ordinary course will come upon the Fund during the earlier years of its existence. The younger subscribers may therefore expect to receive larger increments when the time arrives for them to draw benefits.

Division B. — **For officers at annual salaries, with option of retiring at 65 years of age.**

SUBSCRIPTIONS AND ANNUITIES.

SALARY PER ANNUM EXCLUDING OVERTIME.	Total monthly deduction from pay-sheet for subscription and purchase at any age up to 32 next birthday of five years' status by instalments spread over 20 years.	Reduced monthly deduction for subscription only after status has been paid for.	ANNUITY TO EMPLOYEE.		Widow's annuity continued after her death until the youngest child is 18 years old.
			In the event of incapacity for work, with a status of five years.	Amount by which the annuity will be increased for each year of status in excess of five acquired at date of incapacity, or at date of retirement at, or after age 65.	
£ s. d.	£ s. d.	£ s. d.	£ s. d.	s. d.	£ s. d.
Under 112 10 0	0 18 8	0 13 4	26 0 0	4 0*	20 0 0
— 125 0 0	1 1 0	0 15 0	29 5 0	4 6*	22 10 0
— 137 10 0	1 3 4	0 16 8	32 10 0	5 0*	25 0 0
— 150 0 0	1 5 8	0 18 4	35 15 0	5 6*	27 10 0
— 162 10 0	1 8 0	1 0 0	39 0 0	6 0*	30 0 0
— 175 0 0	1 10 4	1 1 8	42 5 0	6 6*	32 10 0
— 187 10 0	1 12 8	1 3 4	45 10 0	7 0*	35 0 0
— 200 0 0	1 15 0	1 5 0	48 15 0	7 6*	37 10 0
— 212 10 0	1 17 4	1 6 8	52 0 0	8 0*	40 0 0

* This amount as fixed *for the present*, more particularly affects foundation subscribers of 40 years and upwards of age, who in the ordinary course will come upon the Fund during the earlier years of its existence. The younger subscribers may therefore expect to receive larger increments when the time arrives for them to draw benefits.

mined by the sum to be raised, which varies from £75 to £100, according to the age of deceased member at the time he joined; such sum is handed over to the family or nominee. The levies have aggregated to about £1 per member per annum.

The South Australian Railways hospital fund.

This fund provides treatment at hospitals free of cost to the subscribers. The department collects an annual levy of one quarter day's pay from members and hands it over to the executive of the fund. The amount collected is divided among approved hospitals in proportion to the number of members who have been patients, a minimum payment of 15*s*. per week per patient being guaranteed.

MISCELLANEOUS INFORMATION

[621 .152.5]

1. — Mallet duplex compound freight locomotives for the Great Northern Railway (United States).

Fig. 1, p. 123.

(*Engineering News.*)

The great duplex locomotive of the Mallet system which was built about two years ago for the Baltimore & Ohio Railway (*Engineering News*, June 30, 1904, and June 15, 1905) (1), and which was one of the notable exhibits at the St. Louis Exhibition, has now been followed by some very similar but slightly larger engines for the Great Northern Railway. These latter have recently been completed by the Baldwin Locomotive Works, and one of them is shown by the accompanying illustration (fig. 1). The Baltimore & Ohio Railway engine was designed for pusher service on heavy mountain grades, and weighs 334,000 lb., the entire weight being carried on six driving axles arranged in two groups; the three rear axles are carried in the main frames, and the three front axles are carried in a swiveling truck.

The new engines of the Great Northern Railway are intended for use as regular road engines in heavy freight service, and have at each end a pony or two-wheel truck in order to facilitate the passage of the engines around curves of 10°. The total weight is 355,000 lb., being slightly greater than that of the earlier engine, but the weight on driving wheels is somewhat less, 316,000 lb. The earlier engine is of the 0-6-6-0 type, while the later engines are of the 2-6-6-2 type.

The boiler of the Great Northern engine is about the same in size as that of the Baltimore & Ohio Mallet. With a fire-box heating surface of 225 square feet (against 219), and a tube heating surface of 5,433 square feet (against 5,366), the Great Northern locomotive has a steaming capacity about 2 per cent greater than its predecessor. The grate area, 78 square feet (against 72), is increased in somewhat larger ratio. The later locomotive is, however, designed to carry a lower boiler pressure than the other (200 lb. per square inch against 235). In discussions on the Baltimore & Ohio locomotive, the opinion has been repeatedly expressed that steam pressures in excess of 200 lb. are of doubtful advisability, on account of the greater liability to leakage and greater cost of maintenance which they entail. The more conservative pressure of the Great Northern engine no doubt is a concrete expression of this view. The lower pressure is in part made up by larger cylinders; the newer engine has 21·5 inch high-pressure and 33-inch low-pressure cylinders (against 20 and 32 in the Baltimore & Ohio), with stroke the same as in the earlier engine (32 inches).

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(1) Vide *Bulletin of the Railway Congress*, No. 4, March, 1905, p. 1151, and *Proceedings of the seventh session* (Washington, 1905), vol. II, p. V-135.

The boiler and fire-box of the Great Northern engine are carried well above the frames. The latter are of cast-steel. The rear frame, which carries the high-pressure cylinders, is in rigid connection with the boiler, while the forward frame, with the low-pressure engine, swivels around a vertical pin in the center line of the saddle of the rear engine. A rearward extending radial frame bolted to the top of the forward engine frame, projects back to engage with this pivot. The boiler has a bearing near midlength of the forward frame, where a heavy cross-girt of the frame provides a seat for a transverse sliding bearing. The receiver pipe, which carries the exhaust of the high-pressure engine forward to the low-pressure cylinders, swivels at the same point as the forward frame, and is provided with a slip-joint. The exhaust from the low-pressure (forward) cylinders calls for another flexible pipe connection ; the exhaust stand is rigidly fixed in the smoke-box, and the short connection pipe from the top of the low-pressure cylinder casting is fitted with swiveling and expansion joints to accommodate itself to the lateral motion of the forward frame relative to the boiler. The two pony trucks are pivoted by radial frames in the usual way.

The fire-box is of the Belpaire type (for soft coal), with a very slightly curved crown sheet and flat slides flaring outward from the crown sheet to the mud ring. There are two fire-doors. The dome is a steel casting, and being very low, it is fitted with a throttle valve of the Rushton pattern, having side openings. The main steam pipes are carried from each side of the dome to the high-pressure cylinders in front of the rear group of driving wheels. The high-pressure exhaust is delivered to a receiver pipe extending forward between the frames and forked to reach the valve chests of the low-pressure cylinders in front of the loading group of driving wheels (of steam trucks) ; this pipe is of flexible construction as already noted. Balanced slide-valves are used for both high- and low-pressure cylinders. They are operated by valve gear of the Walschaerts type. The reversing gear is operated by a compressed-air device.

The general dimensions of these huge engines are as follows, being given in our standard form :

Driving wheels (12, in two groups)	4 ft. 7 in.
Truck wheels (4, in two trucks)	2 ft. 6 in.
Journals, driving axles	10 × 12 inches.
Wheelbase, driving (each group)	10 ft. 0 in.
Driving (both groups)	30 ft. 0 in.
Total engine	44 ft. 10 in.
Engine and tender	73 ft. 2 $^1/_4$ in.
Weight : On driving wheels	316,000 lb.
On front truck	19,000 lb.
On rear truck	20,000 lb.
Engine, total	355,000 lb.
Engine and tender	503,000 lb.
Cylinders, high pressure (2)	21 $^1/_2$ × 32 inches.
— low —	33 × 32 inches.
Valve gear	Walschaerts.
Slide valves	Balanced.
Boiler, type	Straight-top.
Diameter	7 feet.
Barrel plates	$^7/_8$ inch.
Circumferential seams	Triple and double riveted
Working steam pressure	200 lb.

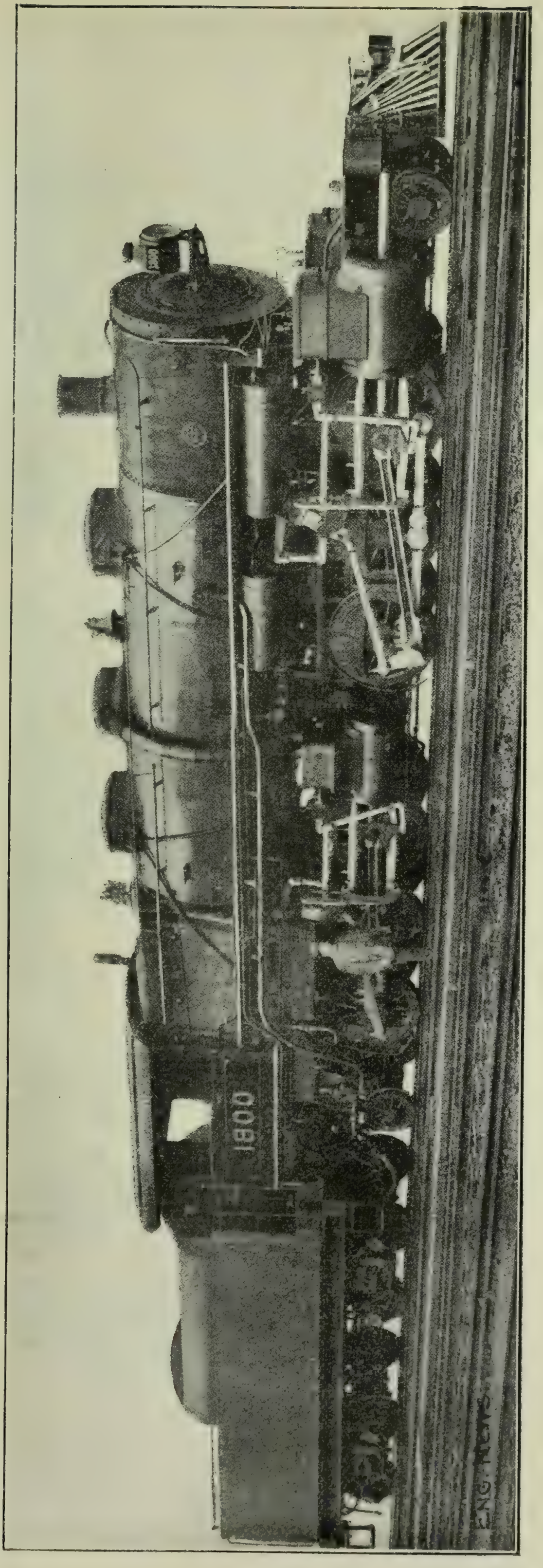

Fig. 1. — Compound duplex on the Mallet system for the Great Northern Railway (United States).

Firebox, Belpaire; size	9 ft. 9 in. × 8 feet.
Depth	At front, 6 ft. 7 $^{1}/_{2}$ in.; at back, 6 ft. 4 $^{1}/_{2}$ in.
Crown, side and back plates.	$^{3}/_{8}$ inch.
Tube sheet.	$^{1}/_{2}$ —
Crown stays, vertical; diameter.	1 $^{1}/_{8}$ —
Water spaces	Front, 6 inches; sides and back, 5 inches.
Tubes; No., 441; thickness	No. 11, W. G.
Spacing	$^{3}/_{4}$ inch.
Diameter, 2 $^{1}/_{4}$ inches; length	21 feet.
Heating surface; tubes	5,433 square feet.
Firebox	225 —
Total	5,658 —
Grate area	78 —
Water in tender tank	8,000 gallons.
Coal in tender	13 tons.
Tractive power (working compound).	71,600 lb.

[625 .143.1 & 625 .143.5]

2. — A non-creeping rail.

Fig. 2, p. 126.

(*Railway Gazette.*)

Rail creeping is more prevalent on British railways than is generally supposed, not only on gradients, where its presence is more or less expected, but also on level stretches of perfectly balanced track it is frequently serious enough to make the adoption of a successful anti-creeping device a matter of importance.

We have recently investigated the claims of a patent corrugated rail made by the Forbes Patent Rail & Grip-Nut Syndicate, Limited, of 25-29, Coleman Street, E. C. As will be seen from the figure 2, this consists of a rail rolled with vertical corrugations on both sides of the web. The inside lip of the chair is cast with corresponding corrugations, and it is claimed that the bearing thus afforded between rail and chair effectually puts an end to creeping. The outer lip of the chair has the accustomed smooth service, but it is found in practice that after a time the keys take on the rail corrugations, thus increasing the tightness of the fastening.

The Forbes rails and chairs have been laid experimentally on two sections of the London & North-Western Railway, on the main line between King's Langley and Boxmoor, and also on the Merthyr and Abergavenny lines in South Wales. On the Welsh section, the gradient is 1 in 38. According to the testimony of Mr. E. B. Thornhill, the Company's Engineer, the rails have undoubtedly stopped creeping at these places and are wearing veey well. The lines in question were selected for the experiment as being places where the largest amount of creeping takes place.

On the Boxmoor section these rails have been laid down on a section of track extending a short distance on each side of the road bridge opposite the Nash Mills signal box. Only the down fast line has been selected, thus affording excellent comparison with the up fast road. The passing of a heavy train at high speed over the corrugated rails, shows a greater steadiness than is attained by the ordinary rails, and the motion of the track is less violent and more rhythmical.

There is undoubtedly very much less tendency for the sleepers to become displaced through constant pounding.

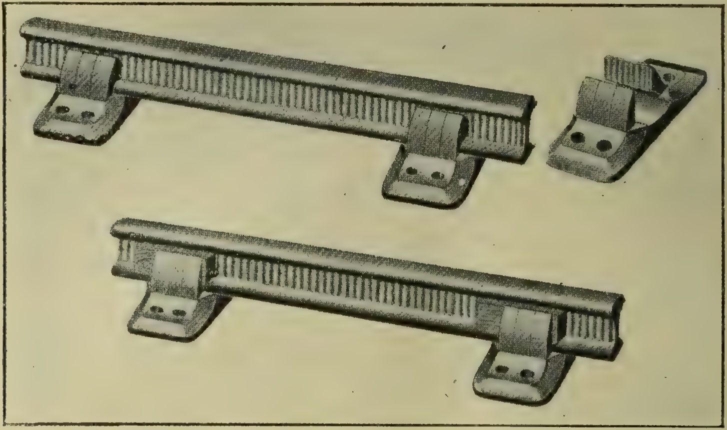

Fig. 2. — A successful anti-creeping device for rails.

On this particular section, the former creeping amounted tosome 2 feet in a year. Since the corrugated rails have been put down, not only are the keys much more firmly fixed, so that their shaking loose has been practically done away with, but the sleepers seem to remain in somewhat better condition. Several other companies have also just taken up the rail and chair, and one of the advantages of the system is that the only modifications required in their manufacture is the small modification required to produce the corrugation. These are imparted in the roll and no material addition is required to the plant.

[625 .251]

3. — Obstruction in brake pipe.

(*Railway and Locomotive Engineering.*)

A remarkable case of failure of brakes to apply when tested, after coupling up and charging, came to light a few weeks ago on one of the large lines between Buffalo and New York. It appears that a few weeks previous to the failure noted, this road had delivered to it a consignment of brand new cars, and they had been in service long enough to get well mixed with the older equipment, and to have the air krakes operated on them many times. Up to the time of the failure to apply, nothing unusual had been observed about the action of the brakes on these cars, but when this particular test was made, it was found that the brake would not apply back of a certain car of the new lot, which happened to be located within a few car lengths of the engine.

As all angle cocks and stop cocks were wide open and all auxiaries in the train found charged, a rigid investigation was instigated to reveal the cause of failure, and the following was the result : a punching, about 1 $^1/_4$ inches in diameter, was found lodged in the pipe in such a position that it practically closed up the passage. This punching being similar in size and shape to many others frequently found lying around the floors of car works, it is inferred that, in some way, while the piping was being prepared one of them accidentally lodged in the end, and worked into the pipe far enough to escape notice, and then worked around inside the pipe until it prevented the brake application.

[625 .255]

4. — Percentage of freight cars equipped with airbrakes in the United States.

(*Railway Age.*)

The Pennsylvania Railroad has reported to the Interstate Commerce Commission for its lines east of Pittsburg and Erie, that 98 per cent of its freight cars are equipped with automatic airbrakes. The New York division of the New York Central reports a similar percentage of cars in that district. On the first of January, 1906, 304 lines reported to the American Railway Association, that 89·8 per cent of their cars were equipped with airbrakes. The amendment to the safety appliance act requires that 75 per cent of the cars in every freight train shall be equipped with power brakes. The remarkable promptness with which the railroads have met the requirements of the Interstate Commerce Commission in the matter of airbrake equipment, is another evidence of the desire of the railroads to obey the law. The cars not now equipped with power brakes, are the old ones having small capacity, and they are principally used in local service and at shops and terminals, so that few of them find their way into main line trains. It is, therefore, easily possible for all roads to operate the brakes on 75 per cent of the cars in a train, and it will seldom be necessary to switch cars not so equipped to the rear of the train. In foreign countries, even England, France and Germany, few freight cars are fitted with power brakes, and this is one reason why freight trains are operated with so much greater efficiency in the United States than in any other country.

[656 .281]

5. — The Grantham accident.

Figs. 3 to 7, pp. 129 and 130.

(*Engineer.*)

Inquiry into the circumstances of the derailment which took place at Grantham on the night of Wednesday, the 19th of September 1906, has so far failed to explain why it occurred. Colonel Von Donop has made the usual inquisition on the spot; but the proceedings are private, and so far nothing is publicly known of the result, save that he may find it necessary to re-open the inquiry to obtain further particulars. The coroner's jury completed their inquiry on Tuesday at Grantham, and delivered a verdict to the effect that " the deceased twelve persons had been accidentally killed; that the driver and fireman were both competent men to work the train, but the evidence was not conclusive to show whether brakes were applied in sufficient time to stop the train at Grantham Station. "

Below will be found a plan of the station (fig. 3), and a statement of all the information that can at present be obtained concerning the facts and circumstances. So far it would appear that the catastrophe remains unexplained. We can do no more here than consider the possibilities of the case; in other words, causes that might have brought it about. An examination of theories is the more desirable because of the wild speculations which have been circulated in the daily press. The first with which we shall deal is the assumption that the brake pipe between the engine and the train had not been coupled up at Peterborough when the engines were changed. As the train stood in the station the brakes must have been hard on, and the new engine could not have moved the train an inch until the driver had "blown the brake off" by restoring the vacuum in the chambers under the coaches. There is only one condition which would nullify the truth of this statement. Some criminal might have walked down the 6-foot and pulled all the release wires under the train and so rendered the brake "dead." But this is quite out of the question. We find then that the brakes were in good order when the train left Peterborough. The evidence goes to show that when the train passed the distant signal at Grantham it was running very fast. Its speed through Grantham Station was high. There is some small conflict of evidence, but so far as is known, it seems to be certain that the brakes were then hard on. Both guards are positive that there was no vacuum in their vans. It must be understood that the vacuum keeps the brake off. As soon as it is spoiled under the pistons, the brakes go on. In each guard's van, there is a large valve; by opening this, the brake is applied. It is purely an emergency valve, and is incapable of the fine adjustments provided for on the footplate. Both guards say that, knowing the train was running too fast to stop at Grantham platform, they went to open their brake valves. One man was knocked down before he could do this, but he seems to have seen that the vacuum had already been spoiled. The other man is quite clear that the gauge stood at zero — that is, atmospheric pressure; consequently the brake had already been applied by the driver. It is to be noticed, however, that the guard who was knocked down took no action until the train had already passed through Grantham some 300 yards or so.

Sensational posters were published by the evening papers on September 24 to the effect that the regulator handle of the engine had been found open, and capital was made of this. It was taken for granted that, the regulator being open, the action of the brakes was neutralised; and on September 26, a daily contemporary went so far as to suggest that the regulator might have broken away from the stop valve inside the boiler, so that steam could not have been shut off. Now about all this it is enough to say that whether the engine is under full steam or not makes a difference of not more than a few yards in the distance which a train will run after the brakes are put on. Many experiments have been made to settle this point, and it is almost startling to stand on the footplate of a locomotive running at, say, 60 miles an hour and witness the promptitude with which the train is stopped under full steam and the reversing lever in the last go-ahead notch. But even if this were not the case, the engine, though running at full speed with steam on, could easily be reversed by the screw gear, now all but universal except on old-fashioned engines of the smaller class.

Two theories are thus disposed of; we come now to the only explanation that appears to us to be plausible. It is that, running down hill as he did from Peterborough to Grantham, the night being dark and wet, poor Fleetwood, the driver, lost his bearings, got to Grantham before he expected it, and at once applied his brakes. But the rails were, we believe, greasy, and would not hold well. Not unnaturally the driver put the brakes on hard, and the wheels immediately picked up, and the coefficient of friction then fell off to about 60 per cent or less of what it would have been if the wheels had continued to revolve. The train pursued its way through Grantham, and then ran off the road. So far our theory is at least plausible. Now comes the true crux.

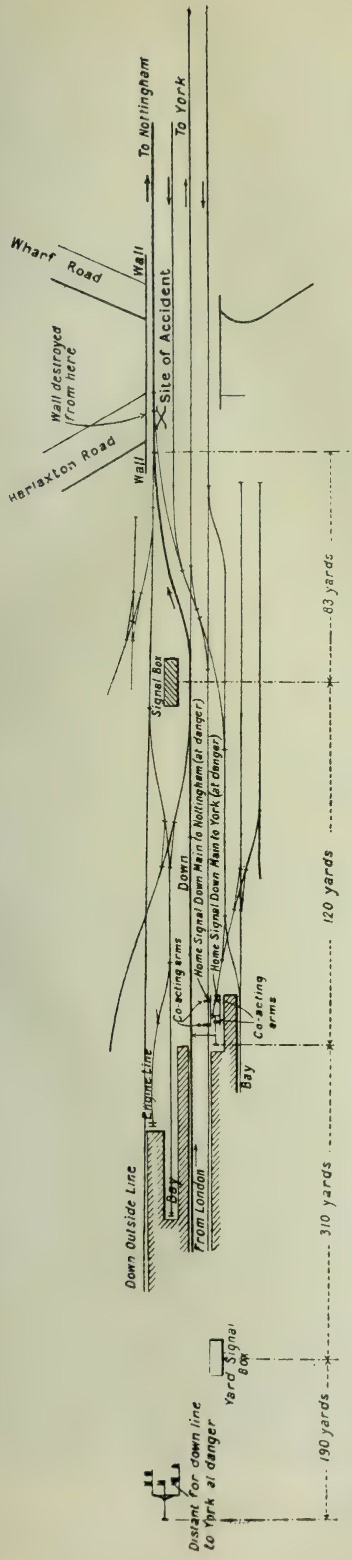

Fig. 3. — Grantham station.

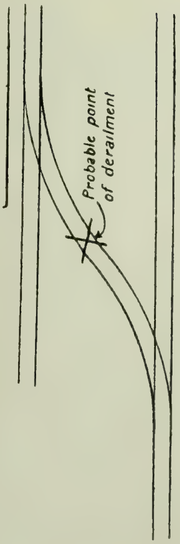

Fig. 4. — Possible site of derailment.

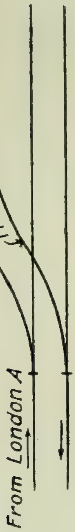

Fig. 6. — Position of the points.

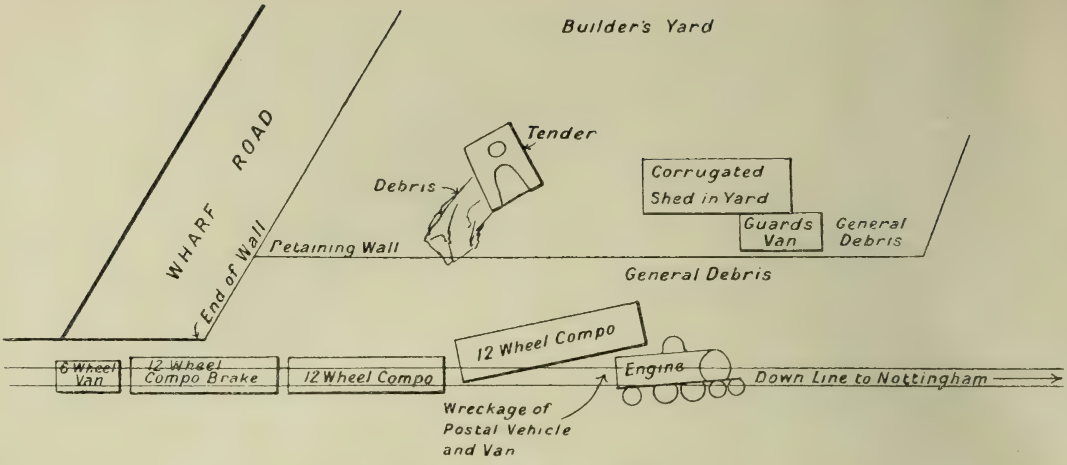

Fig. 5. — Position of wreck.

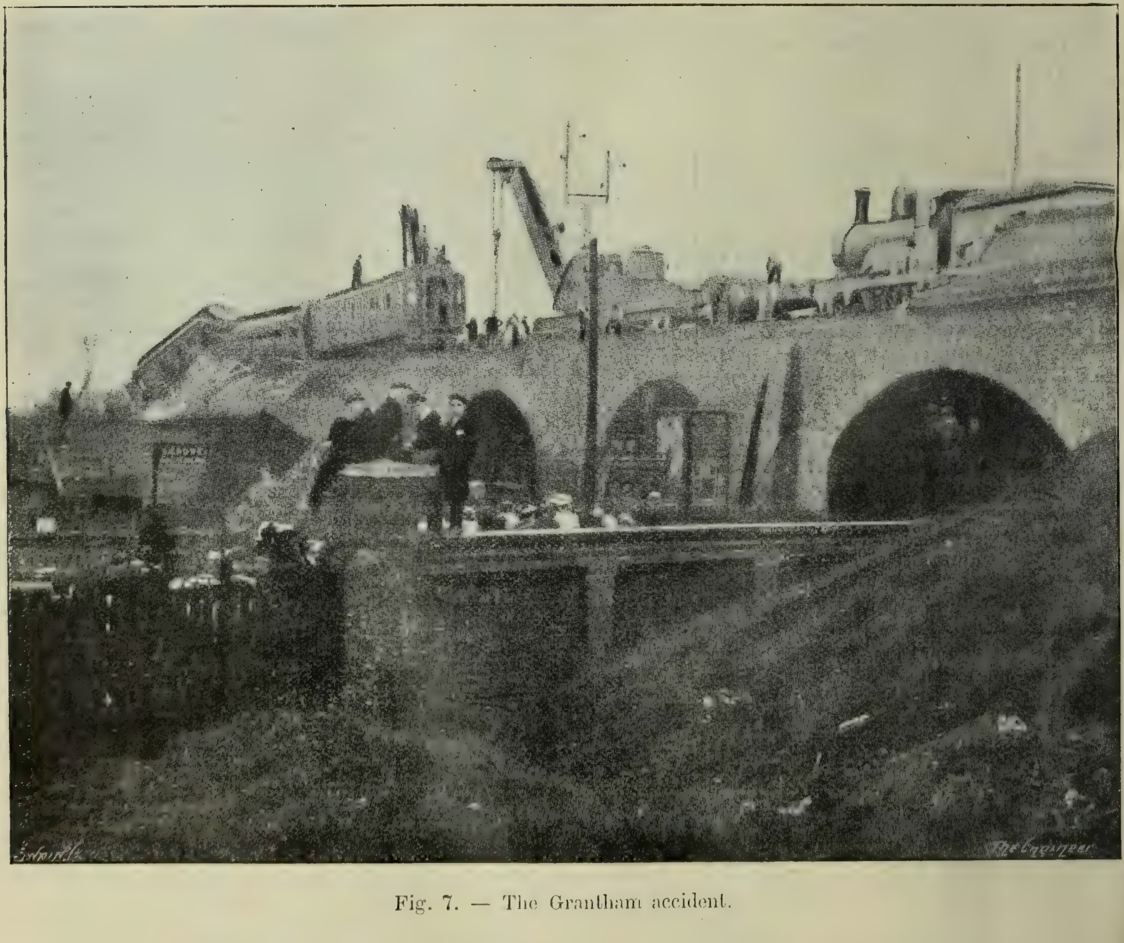

Fig. 7. — The Grantham accident.

Why was it derailed? For the answer to this question we must, we fear, wait for Colonel Von Donop's report. If the brakes were put on in the station, the speed of the train ought to have been so far reduced that the curve would have been traversed in safety. In an ordinary service stop, a train running at 60 miles an hour is brought to a stand in about 450 to 500 yards. Running down 1 in 200 another hundred yards would have to be added. The distance from the distant signal to the point where derailment of some kind probably took place was, as will be seen from our map of the station (fig. 3), about 660 yards. If the brakes were used under "emergency" conditions, and the wheels did not pick up, the service distance would be reduced by at least 200 yards. The derailment presents some peculiar features. It is not at all certain that the engine ran off the track. The possibility is that it was pushed off. Behind the tender were three six-wheeled coaches, which did not weigh more than 14 or 15 tons each, or not more than, say, 2 1/2 tons per wheel. It will be seen that the tender was cut out of the train in a very curious way and flung down the embankment. To interpret the circumstances is a far more difficult task than appears at first sight.

And so the matter stands. We believe we have put forward the only explanation consistent with all the facts and circumstances, but we do not pretend to know all the facts and circumstances; indeed, that knowledge was only in the possession of two men — Fleetwood, the driver, and Talbot, who was firing for him. An attempt has been made to show that because Talbot was a "gentleman apprentice" he was incompetent. It is a pity that those who make accusations of this kind have not had a little footplate experience to compel their silence. Incompetent firemen could not discharge the duties of the highly competent men who only can keep steam for a modern express train. As to the comments which have been made on the system of working the Nottingham points, it is enough to say that it is necessary, and involves but an infinitesimal legitimate risk. Why is it that certain of our daily contemporaries seem to be incapable of learning the simplest lessons concerning the working of railways?

This leading article of *The Engineer* is succeeded by the following account which expounds the circumstances in which the mysterious Grantham accident happened.

For some weeks there have been appearing in the pages of *The Engineer* letters from correspondents on the subject of "Unexplained Railway Accidents" (1). To the list of unexplained accidents must now, apparently, be added the most serious of all, that at Grantham on the night of the 19th of September, when twelve lives were lost owing to the derailment of the 8.45 p. m. Great Northern Scotch express from King's Cross.

Such a disaster, coming so soon after that at Salisbury (2), naturally creates an unfavourable impression on the mind of the public here and abroad that our railways are losing the high standard so long enjoyed for comparative immunity from accident. Our record is certainly getting tarnished. In 1905 there were 39 people killed by accidents to trains which, if the years 1889 and 1879 are excluded — when 80 out of a total of 88 were killed in the Armagh disaster, and 73 out of a total of 75 were drowned by the failure of the Tay Bridge — is the worst year since 1874, the year of the Thorpe and Shipston catastrophes. But the year 1906 is already worse than 1905. In a derailment and subsequent collision on the Caledonian one life was lost, another was lost on the same line by a derailment; and 28 persons were killed at Salisbury, so that the total for 1906 has already reached 42. It is perhaps, however, some consolation to know that the number of persons that met with casualties by accidents to trains has grown less year by year, and no doubt this applies to the year 1906 also. If the number of derailments and collisions may be taken as a criterion of the safety of British railways, then it will be a satisfaction to know that the record for the year 1905, when the average number of collisions and derailments is balanced against the number of miles run, has only once been bettered during the last ten years.

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(1) An article on the same subject was published in the *Bulletin of the Railway Congress*, No. 2, February, 1906, p. 375.

(2) See *Bulletin of the Railway Congress*, No. 8, August, 1906, p. 1341, and No. 10, October, 1906, p. 1639.

It should be put upon record, too, that the Great Northern Company bear a very good record in this and other respects. Out of over 22 million miles run in the year 1905, it had only six collisions and derailments, and takes the second-best place for this amongst the leading companies. Its previous fatal train accidents occurred over ten years ago — that at St. Neots (1) through a broken rail, and that at Little Bytham (2) through excessive speed over a newly-repaired road, the flagman having been prematurely withdrawn.

The train to which the present accident occurred was the 8.45 p. m. express from King's Cross to the North. Whilst described generally as a Scotch express, it is not on the same high level as to speed and equipment as the other night trains, like the 8.15 and 11.30. It is really the Great Northern mail, and carries a postal sorting van to Newcastle. It has also a sleeping car, which serves not only those passengers from London who desire to travel by it, but those from stations at which the faster trains do not call. On the night of the 19th, there were two sleeping cars, but the second was being worked north empty to provide accommodation for tourists returning south.

At Peterborough engines were changed, and No. 276 was attached. This is one of the 4-4-2 class. It was in charge of driver Fleetwood and fireman Talbot. At the coroner's inquest, held on the 25th of September, it was shown that engine No. 276 arrived from the North earlier in the evening, turned and took in water, and, as the engine crew were limited for time, assistance was given them in getting the coal forward on the tender. The men were both apparently in good and fit condition, and the only comment made by the driver was that he lost eight minutes in running the previous night, for which he was not going to stand the blame. This loss of time, it was stated at the inquest, was due to the tubes leaking. Proof was given at the Board of Trade inquiry that the continuous brake was properly coupled and in good order, but the coroner did not think this was material for the inquest.

The train was due to leave Peterborough at 10.20, and to arrive at Grantham at 11, so that forty minutes are allowed for the run of 29 miles. For no non-stopping train is more time given than this, whilst some others have only thirty-five and thirty-eight minutes. The train was practically on time and the load was not excessive. The train was made up as follows : Engine, tender, 6-wheel van, 6-wheel postal van, two 8-wheel vans, 6-wheel third class, 6-wheel composite, two 12-wheel sleeping cars, three 12-wheel composites, and one 6-wheel brake — a total of twelve vehicles and 106 wheels, with a brake application to 76 wheels. Five and a-half miles south of Grantham is a tunnel which forms a good landmark. Two miles further is Great Ponton Station. South of Grantham Station there are three signal-boxes — Saltersford, Grantham South, and Grantham Yard Box. The latter is at the south end of the up platform of the station, and the others are about half a mile apart. The gradient is 1 in 200 and falls towards Grantham. A former fireman of Fleetwood's in his evidence before the coroner said that it was Fleetwood's practice to check his train soon after leaving the tunnel, to shut off steam altogether at Saltersford distant signal, then put on the brakes steadily, and afterwards continue to apply them. This man said further that Fleetwood did this invariably, whether he was going to stop at Grantham or not. In this Fleetwood was only working to rule, as it is one of the standard regulations to test the continuous brake before reaching any point at which a stop has to be made, also before entering terminal stations, under which heading Grantham is placed.

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(1) See *Bulletin du Congrès des chemins de fer*, No. 3, March, 1896, p. 271, and No. 7, July, 1896, p. 883.

(2) See *Bulletin du Congrès des chemins de fer*, No. 4, April, 1896, p. 427.

The signal-box at the other end of Grantham Station is Grantham North Box, and worked therefrom are the junction home signals seen at the north end of the up platform in figure 3, and the corresponding distant signal under the home signal at the Yard Box. The North Box home signal was at danger, also the distant, but all the signals south thereof and applicable to the train were at " clear. " As the train was due to stop at Grantham there was nothing irregular in that. For some reason that will probably never be known, as both the driver and fireman were killed, the train did not pull up in the station but ran right through at a high rate of speed, and, following the course indicated by the thick line in figure 3, was turned on to the Nottingham line. The train apparently took the curve all right, but when it reached the spot marked by a cross in figure 4, where the direction of the curve is reversed, the impetus would not allow it to follow the rails, so that the engine was derailed, fell over on its left side, and striking the wall, was carried about 100 yards past the end of the wall.

The diagram in figure 5 gives an idea as to what became of the train. The engine was on its left side, with its smoke-box dented in and the chimney and cab swept away. The tender went away to the left and down the bank. What became of the first van is not clear, but the postal van and the first of the eight-wheel vans followed the engine, came into collision with it, and were destroyed. The next three vehicles evidently jumped over the engine and went down the bank. The third-class coach and the composite were destroyed, and the van less so. It was in this that the leading guard rode, and from which he escaped through a window. The sleeping cars were destroyed. The first of the three twelve-wheel composite carriages came to rest fairly upright against the engine, and was destroyed by fire from the engine. The last three vehicles were practically on the rails. Some of the vehicles, and the damaged wall, are seen in figure 7.

Leaving for a moment the consideration of the original cause of the disaster — the train not stopping in the station — we come to the contributory causes : *a*) the position of the facing points which turned the train on to the Nottingham line, instead of allowing it to continue on the main, and straight, line; and *b*) the formation of the facing connection, which contributed, if it did not actually lead, to the derailment. The coroner's jury added a rider as to these matters to their verdict of accidental death, which was to the effect that it would be safer if a wider curve were made at the Nottingham branch line, and if the points on the main line at the junction in question were set clear as soon as a train had passed.

Let us consider these two suggestions. First, then, as to the position of the points. If the diagram of the line shown in figure 6 be referred to, it will be seen that in line with the facing points A in the down main, there are in the up main trailing points B for the line from Nottingham. It is one of the standard rules of signalling and interlocking that the levers working these two sets of points should be so interlocked that before points B are pulled and the " road is set" — to use a railway phrase — for a train to come from Nottingham, the points A in the down line must be made to lie for the Nottingham direction, so that if a down train overran its signals it would be turned on to the Nottingham line, and not cut through the train from Nottingham. This is an ever-present safeguard, and must not be removed. It also facilitates traffic, as, if the points A on the down line must be set for the York line when a train is approaching, all traffic from Nottingham is held up, and *vice versa,* when a train is approaching from Nottingham, the points B must be set for Nottingham, so that all trains from London will be kept back. Further, there is an overrun of 120 yards between the home signal and the facing points which ordinarily should be sufficient. The interlocking, in our opinion, is therefore correct, and as the schedule of working called for a stop of five minutes in the station, the signalman was, again in our opinion, justified in leaving the facing points set for the Nottingham line — in which position they had just previously been placed in order to allow the trailing points to be set for a train from Nottingham — so that he could deal with any other trains coming from Nottingham.

As to the curve, it must be admitted that it is not laid out for fast running. There is a speed limit of 15 miles ordered, but the question arises as to the necessity for improvement. It is really an emergency crossing, as there are no regular passenger trains that run through without calling at Grantham. As will be seen from the diagram in figure 1, the position of the connection is tied down by other connections, the disturbance of any of which will call for considerable inconvenient alteration.

We have dealt above with the possible cause of the driver not stopping at Grantham. It need only be said here that whilst driver Fleetwood had lost some time in 1906 through illness, yet his complaint — sciatica — was not of a nature to incapacitate him bodily, and not at all mentally, and excellent testimony was borne by his superiors as to his character. Talbot, his fireman, had been a premium apprentice, and much has been made of this; but we are thankful that the coroner cut short any attempt on the part of the trades union representatives to deal with this at the inquest. It is therefore a relief to hear that Talbot had "gone through the mill," and, in the opinion of the district locomotive superintendent, had exceptional experience, and one of his former drivers said he was very clever with his shovel and in everything he had to do.

There is one other point that must be referred to, and that is an outbreak of fire that subsequently occurred. The live fire from the engine had something to do with this, as it certainly destroyed the postal vehicle and second van, whilst the twelve-wheel coach that also lay up against the engine and was burnt was lighted by electricity. We feel sure that Colonel von Donop, who has conducted the inquiry for the Board of Trade, will look into this matter, as he had the case before him of a vehicle on fire after the Witham derailment (1), and he also referred to the subject of gas-lighted coaches in his report on the derailment in Catesby tunnel.

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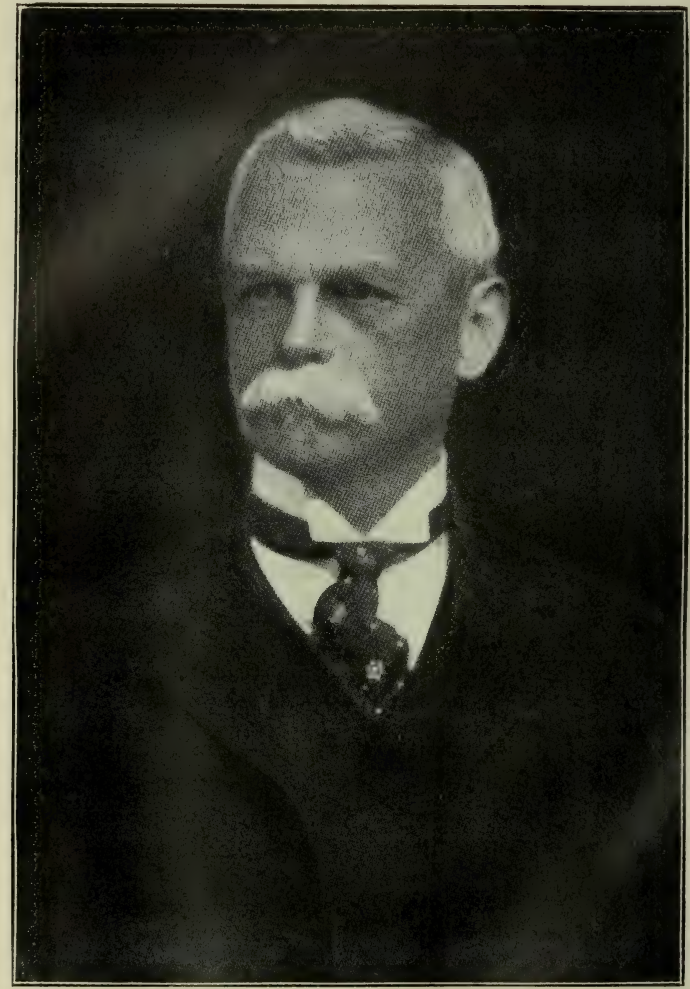
(1) See *Bulletin of the Railway Congress,* No. 1, January, 1906, p. 274.



Samuel Spencer.

[385. (09.2)]

OBITUARY

Samuel SPENCER,

President, Southern Railway,
Member of the Permanent Commission of the International Railway Congress-Association,
Delegate to the session of Washington (1905).

To the soil of Virginia, not far from his Alma Mater, on the railroad that had been his charge in early manhood, and an integral part of the system welded together by him in his maturity, Samuel Spencer almost literally yielded his ashes on Thanksgiving morning. On the day that the Nation lifted its voice in gratitude for the manifold blessings of its civilization, he was killed by the instrument he had almost created and had developed to diffuse those blessings, and enhance that civilization throughout the region of his birth, to whose welfare his devotion was unceasing.

The fine old strain of the Spencers and of the Harrisons — the family that has given a signer to the Declaration of Independence and two Presidents to the United States — were blended in this man who graduated at the head of his class at the University of Georgia, and at the head of his class when he completed a subsequent course at the University of Virginia.

He had chosen a course in civil engineering, thus displaying the foresight that marked his career ; although but a lad of 18 at the close of the war he saw that railroads were needed, and he thereupon fitted himself to build them. After three years of field service in construction he perceived that there would be a crying need for men to run the railroads that were extending far and wide, and he beset himself to learn the detail of operation. In this he became proficient through seven years of service, as a clerk in the office of the superintendent of the New Jersey Southern, assistant supervisor of trains, and supervisor of trains of the Baltimore & Ohio, superintendent of transportation of the Virginia Midland, and general superintendent of the Long Island Railroad. He never had a friend at court but his promotion was invariably rapid.

After Spencer had left his service, John W. Garrett, the President of the Baltimore & Ohio, discovered that he had lost a good man, and finally, in 1879, persuaded him to return as assistant to the President. In this position his experience broadened. Mr. Garrett, who had gained in years and lost in vigor, allowed his clear-headed and indefatigable assistant to unravel problems in traffic and accounts, as well as in construction and operation. A conspicuous achievement was the straightening out of the operation of the Trans-Ohio lines, of which he was made Acting General Manager for that purpose. Before long the actual practical administration of the Baltimore & Ohio fell to him. This condition continued during the administration of Robert Garrett, who gave his attention to the extension to Philadelphia and to the projects for entering New York. With these Mr. Spencer had little or no connection, but he was the virtual head of the existent Baltimore & Ohio system. In 1887 the financial interests that desired to conserve the property insisted that he be made the actual President. While in this position he sought to perform a long-needed surgical operation upon the company's accounts. The valuation of its assets on the books had long been grossly in excess of a reasonable appraisal. Cars and locomotives had been destroyed, and were placed out of commission for one reason or another, without being replaced; docks and wharves had worn out; money had been lost in branch lines, but no deduction had been made from the valuation, nor had allowance ever been made for depreciation. The cut that Mr. Spencer made was not nearly so radical as the circumstances demanded, but it wounded the pride of the majority stockholders, who were devoted to the memory of the Garrett regime, and he was not re-elected. Mr. Spencer's attitude was based upon clear perception of and invincible courage in facing the facts. Had it been accepted, the next few years in the history of the Baltimore & Ohio might have been of steady recuperation, instead of the deepening disaster that led to the receivership.

Mr. Spencer's services were immediately enlisted by Drexel, Morgan & Company (the firm now designated as J. P. Morgan & Company). Their investments in railroads and railroad securities were extending, and they needed the guidance of a man expert in all that pertained to railroads. Thus Mr. Spencer's courage and ability were given opportunity in a still broader field. He had to arrive at the status of this railroad and that railroad in different parts of the country, of different construction, beset with varying traffic problems, and serving communities of different characteristics. He had learned what constituted good construction good operation and good direct administration, and now, through more immediate contact than before with financial problems, he developed the capacity to look at a railroad from the standpoint of the investor; he learned what was necessary to a presentation and how to make the presentation that would command respect in the banking capitals. Incidental to his connection with the Morgans, he regenerated and revivified several poorly built and badly conducted railroad properties, and at the same time on behalf of the City of New York, gave much attention to the Rapid Transit Commission, of which he was a member from 1891 to 1893, and as a member of the Brooklyn Bridge Commission helped to design the present terminal structures, which doubled the capacity of the bridge.

In 1893 came the event which led to the crowning achievement of his career — his appointment as receiver of the Richmond & Danville, and of the East Tennessee, Virginia & Georgia railroads. His extraordinary experience, together with his thorough knowledge of the South, led to the inception of the plan whereunder a number of the southern railroads that had separately struggled along to bank-ruptcy, could be united in a mutually co-ordinating system. Thus arose the Southern Railway Company, of which he became President. Bit by bit the system extended until it formed a channel for every important traffic current of the South, its lines reaching from the great cities of the seaboard throughout the Southern Atlantic States to Florida; through Atlanta to Memphis and New Orleans; from Cincinnati and St. Louis to the Gulf, and to the southeast. This bringing together of separate railroads required great care and patience; but the principal obstacle to successful operation was the run down condition of the roads and their equipment. The desolation wrought by the war had not been repaired before the depression of the panic of 1873, and the panic of 1893 fell with distressing severity upon the South. The Southern Railway was obliged to demonstrate its ability to exist before investors would entrust their funds with the company. Year by year it struggled along, rebuilding track and structures and providing new equipment as rapidly as earnings would allow. Then came the great revival of industrial and commercial activity. The demands upon the railroads all over the United States greatly overtaxed their capacity; there were not tracks enough, nor equipment enough, and trained and skilled employees in adequate number could not be obtained. These conditions were aggravated in the South, which entered upon an era of growth exceeding in ratio that of the more regularly developed regions. The Southern Railway Company continued to meet the conditions as best it could. Its earning capacity was finally thoroughly established; a bond issue of $200,000,000 was authorized at the beginning of this year. The proceeds of this issue will permit the practical rebuilding of the system. The main lines, however, are well built, well equipped and well operated at this time, the delays not being incommensurate with those on other railroads that have likewise been overwhelmed with the marvelous and continually increasing volume of traffic. At this writing there is nothing to show that the cause of the wreck was other than an error of an operator at a block signal tower. Unexpected flaws in the working of the human brain cannot be eliminated even by the most careful railroad management, any more than can the coming to light of unexpected and undetectable flaws in material and structure.

In the relations of the administration of a railroad company to its employees, Mr. Spencer was thoroughly grounded during the earlier years of his career; into its relations to the investing public he gained a complete insight while with J. P. Morgan & Company, and during that period his eyes began to be opened to another relation of paramount importance, to the elucidation and cultivation of which the railroad presidents as a whole had given but little attention; that is, the relation to the general public considered not as shippers or consumers, but as the power behind the government.

That there have been abuses in railroad administration has been widely known and admitted by no one more freely than by Mr. Spencer. The actual abuses are insignificant beside the excellence of that administration in general and its beneficent results as a whole is not so widely known, nor freely admitted by all of those who know. That the clamor of recent years against the railroads has sprung largely from ignorance of the principles underlying railroad practice, and has been fomented by those desiring an increase of political power; those who have not adjusted their affairs to the changing economic currents, and those whose vague discontent with existing conditions, leads them, without analysis, to attack whatever confronts them. All this Mr. Spencer knew, and he realized what the ultimate consequences will be if the cause of the railroads is not made clear to the popular understanding.

To the presentation of this cause he freely gave his pen and his voice. His style of expression was as was the man — simple, direct, vigorous, comprehensive in sweep, but of concentrated lucidity. When the agitation for additional railroad legislation resulted in the passage by the House of Representatives of the Esch-Townsend bill in the spring of 1905, the presidents of the railroads, alarmed at last by the proposal to give unrestricted authority to make railroad rates and to determine railroad practices for the entire country to a body of five men sitting in Washington, asked Mr. Spencer to act as their spokesman and representative. In the following year he gave to this mission much of his time and energy. The inherent fairness of his mental processes, the vigor of his thought and expression, and his transparent sincerity are indicated by this oft-quoted extract from his address before the Traffic Club of Pittsburg, April 7, 1905 :

" Strengthen the laws in condemnation of rebates, secret devices and unjust discrimination to any extent that may be found possible, and provide, if such further provision be still necessary, for the prompt arraignment and prosecution of all offenders of the law in the duly constituted courts of the country, and for the unsparing punishment of those who are found to be guilty. If there are such offenders in the railroad fraternity, their offences should be exposed and punished, but it is un-American and unfair, not to say outrageous, because it is alleged there are such, that every manager, and every president and director, shall be subject to indiscriminate public condemnation, and that the innocent investors shall have their property jeopardized, and their rights infringed, because those to whom the prosecution of the law is entrusted fail to find the offender, and to punish him. "

It is noteworthy that prior to this clarion proclaim there had not been a single prosecution of any railroad for rebate giving, although the Elkins law had been in effect for two years; but since its utterance the Federal government, that had been crying for more law, began to enforce the law then existent, under which, during the last year and a half have been conducted the prosecutions and imposed the penalties for rebate giving.

In his last public address, which was delivered before the Agricultural Association of Alabama, at Montgomery, on October 25th, Mr. Spencer said :

" Everything relating to the business interests of the people has been drawn into the arena of excited popular sentiment and debate. The honesty of fiduciary relations, the accountability of men of great power and great wealth to their fellow men, the regulation and control of so-called trusts and of quasi-public utilities, have received the focussed attention and excited the universal interest of the people. Under the influence of their aroused and determined purpose, some gross abuses have been uncovered. Prompted by these disclosures it is little to be wondered at that the popular judgment has become disturbed and the conclusion hastily and unjustly reached that all important interests merit popular suspicion and distrust. "

As the representative of the railroads during the rate regulation controversy, Mr. Spencer relied upon the candid presentation of logical argument to reasoning minds. During the session of the 59th Congress, that passed the Hepburn Bill, there was no railroad lobby at Washington. Although contrary to general rumor and the popular belief, this is the absolute truth. Mr. Spencer insisted not only that there must not be a lobby, but that there must not be the semblance of a lobby.

Mr. Spencer was short in stature, slender, well-knit and amazingly alert in his movements. His fine face and beautiful head indicated his stately lineage, his sturdy honesty, and his great and well balanced intellect. Not only was his mind broad in grasp and keen in penetration, but during the continuously pressing incidents of his ever busy days, it turned with extraordinary rapidity from one subject to another and held the details of each in a marvellous memory. When tasks demanded attention more prolonged than could be taken from the pressure of his office, it was his wont, during the portion of the year passed in New York, to steal away after office hours and go with his secretary to one or another of the hotels — to which one, no one knew save his confidential clerk at his office — and there they not infrequently would work until well into the morning. This great energy was fostered by habits that were moderate to the point of abstemiousness. While under the strain that always marked the hours at his desk, Mr. Spencer once or twice in the morning, and once or twice during the afternoon, would ask for a glass of water; as he drained it fatigue seemed to vanish.

When the writer was asked to prepare this review, he was requested that it be " not merely a tribute, but a discriminating analysis of his virtues and faults. " Thereupon, he said to Mr. Spencer's senior secretary : " Now tell me what were Mr. Spencer's faults. " That veteran of 30 years in the service of his chief, calmly and deliberately said : " He hadn't any. " That is also the statement of the writer, whose own association with Mr. Spencer was close and continuous for a year and a half. In all the relations of life he was clear and clean-cut, punctilious in rendering to every man his due. His keen and direct perception and power of logical and terse expression made him at times impatient of a statement that was long in words and lacking in logic, but this was a virtue, not a fault. Toward the close of a busy day, after he had been battered with letters and telegrams, and callers and board meetings, there sometimes was the display of irritability. This is the very worst that can be said of him; and this is only to say that he was human. To any one who knew the tremendous demands made upon both this body and his mind, the wonder is that the display was not the rule instead of the exception. The trait upon which the men who have been associated with him longest and knew him best especially dilate was his absolute conscientiousness in all things great and small. He did not utter himself, nor permit his subordinates to utter for him, even the fib, the white lie of convenience, but he could parry with the best.

This recountal depicts, without exaggeration, the man whose life was taken on Thanksgiving morning It is trite to say, that could there have been the foreboding of the disaster in his mind, its most deplorable feature would have been the death of his friends and his servitors that occurred at the same time as his own.

Mr. Spencer was a director in nine railroad and financial corporations; he was active in each board, and held high in the esteem of its members, as evinced by the resolutions they have passed to his memory. He was 59 years old; at the height of his career; without either mental or bodily infirmity; he was never a speculator, leaving a fortune that is but moderate, when his environment and opportunities are considered. His domestic life was of great happiness; his success in rearing a family in no wise being surpassed by his success in business.

(*Railroad Gazette.*) LOGAN G. MCPHERSON.

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I. — BIBLIOGRAPHY OF BOOKS

(December, 1906.)

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1906 **385** .581.1

BOISTEL (Julien), sous-chef de bureau au ministère du commerce, de l'industrie et du travail.

Manuel pratique pour l'application de la loi sur le repos hebdomadaire.

Paris, librairie Chaix. (Prix : 1 fr. 50 c.)

1906 **351** .812

LAMÉ FLEURY (E.), inspecteur général des mines, & **SARRUT** (Louis), président de Chambre à la Cour de cassation.

Code annoté des chemins de fer en exploitation ou recueil méthodique et chronologique des lois, décrets, etc., concernant l'exploitation technique et commerciale des chemins de fer.

Paris, librairie Chaix. 4e édition, 1 volume in-8° de plus de 1,200 pages. (Prix : 20 francs.)

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Melun, Imprimerie administrative. In-4°, VI-573 pages. (Prix : 5 francs.)

1903 **313** : **625** .6 (.44)

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Melun, Imprimerie administrative. In-4°, 494 pages. (Prix : 5 francs.)

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Le bilan d'un siècle (1801-1900). T. 2 : Mécanique générale. Électricité. Génie civil et moyens de transport.

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1906 **656** .235

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Poligny, imprimerie Jacquin. In-8°, 48 pages. (Prix : 1 franc.)

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[1] The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels. (See "Bibliographical Decimal Classification as applied to Railway Science," by L. WEISSENBRUCH, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

N. B. — The Monthly Bibliography is printed on one side only so that it may be cut up into slips and pasted on labels for catalogues and indexes

1906 **621** .336. (01

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Théorie et calcul des lignes à courants alternatifs. Traduit de l'allemand par E. Steinmann, professeur à l'école de mécanique de Genève.

Paris, Ch. Béranger. 1 volume in-8°, 60 figures dans le texte et 7 planches hors texte. (Prix : 12 francs.)

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Les turbines à vapeur. Ouvrage suivi de considérations sur les machines thermiques et leur avenir ainsi que sur la turbine à gaz. Traduit d'après la 3e édition allemande par E. Hahn, directeur du laboratoire de mécanique appliquée à l'université de Nancy.

Paris, Dunod & Pinat. In-8°, VIII-636 pages, 434 figures. (Prix : 25 francs.)

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Verkehrsentwicklung in Deutschland, 1800-1900.

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— — Nr 46, 17. — p. 1867.

DIETERICH (G.). — Die Erschliessung der nordargentinischen Kordilleren mittels einer Bleichertschen Drahtseilbahn für Güter und Personen. (6,000 Wörter, 1 Tabelle & Fig.).

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin)

1906 **385**. (09.1 (.73)
Zeitung des Vereins, Nr 80, 17. Oktober, p. 1247.
— Nr 81, 20. — p. 1263.

GIESE (E.). — Einige Bemerkungen über die Bahnanlage in Nordamerika. (3,600 Wörter & Fig.)

1906 **385** .15 (.436)
Zeitung des Vereins, Nr 80, 17. Oktober, p. 1251.
— Nr 81, 20. — p. 1265.

Die Verstaatlichung der Kaiser Ferdinands-Nordbahn. (5,600 Wörter.)

1906 **625** .13
Zeitung des Vereins, Nr 82, 24. Oktober, p. 1279.
— Nr 84, 31. — p. 1314.

BERDROW (W.). — Der Simplontunnel. (6,000 Wörter.)

1906 **656** .222.1 (.434)
Zeitung des Vereins, Nr 82, 24. Oktober, p. 1283.

KUNTZEMÜLLER (A.). — Die Fahrgeschwindigkeit auf den badischen Eisenbahnen. (1,200 Wörter & 1 Tabelle.)

1906 **625** .24 (01
Zeitung des Vereins, Nr 83, 27. Oktober, p. 1295.

MÜLLER. — Güterwagen mit erhöhter Ladefähigkeit und mit Einrichtung zur Selbstentladung. (1,000 Wörter.)

1906 **656** .211.7
Zeitung des Vereins, Nr 84, 31. Oktober, p. 1311.

BALTZER (F.). — Der Eisenbahnfährdienst zwischen Stralsund und Rügen und das neue Fährschiff « Bergen ». (2,000 Wörter.)

1906 **656** .234 (.45)
Zeitung des Vereins, Nr 85, 3. November, p. 1327.

Eine Reform der italienischen Personentarife. (800 Wörter & 1 Tabelle.)

1906 **656** .2 (01
Zeitung des Vereins, Nr 86, 7. November, p. 1343.

SIGEL. — Der Entwurf einer neuen deutschen Verkehrsordnung. (4,800 Wörter.)

1906 **625** .175
eitung des Vereins, Nr 87, 10. November, p. 1359.

KOLL (F.). — Benzinmotor-Draisinen. (1,000 Wörter.)

1906 **385** .113 (.433)
eitung des Vereins, Nr 87, 10. November, p. 1362.

Betriebsergebnisse der bayerischen Staatseisenahnen im Jahre 1905. (2,400 Wörter.)

1906 **385**. (09.1 (.7)
eitung des Vereins, Nr 88, 14. November, p. 1375.

ERBSTEIN (A.). — Die panamerikanische Eisenbahn. ,600 Wörter & 3 Tabellen.)

1906 **656** .222.1
eitung des Vereins, Nr 88, 14. November, p. 1379.

SCHULZE (W. A.). — Fahrgeschwindigkeitsrekord uf deutschen Eisenbahnstrecken. (800 Wörter.)

1906 **656** .235
eitung des Vereins, Nr 89, 17. November, p. 1391.

PITSCH. — Annahme der Güter auf grossen Staonen. (1,900 Wörter.)

1906 **625** .142.2
eitung des Vereins, Nr 89, 17. November, p. 1394.

LIEBENSTEIN (Frhr. v.). — Neuere Holztränkungserfahren. (1,700 Wörter.)

1906 **625** .236
eitung des Vereins, Nr 90, 21. November, p. 1407.

GUILLERY (C.). — Staubsaugeanlage mit Betrieb rch Druckluft. (1,800 Wörter.)

1906 **656** .254
eitung des Vereins, Nr 91, 24. November, p. 1423.

MARTENS (H. A.). — Nachrichtengebung vom hrenden Zuge. (1,000 Wörter.)

Zentralblatt der Bauverwaltung. (Berlin.)

1906 **656** .211.4 & **725** .31
entralblatt der Bauverwaltung, Nr 91, 10. November, p. 580.

EVERKEN. — Die neuen Bahnhofsanlagen in und ei Wiesbaden. (1,700 Wörter & Fig.)

In English.

American Engineer and Railroad Journal. (New York.)

1906 **621** .132.4
merican Engineer & R. Journal, No. 11, November, p. 411.

Cole four-cylinder balanced compound Pacific type comotive. (1,500 words & fig.)

1906 **621** .134.3
American Engineer & R. Journal, No. 11, November, p. 426.

COSTER (E. L.). — The mathematical analysis of the Walschaert valve gear. (1,400 words & fig.)

American Machinist. (New York.)

1906 **51**. (08
American Machinist, No. 44, November 17, p. 555.

KENNEDY (H. J.). — An ingenious calculating machine. (5,000 words, tables & fig.)

1906 **727** .4
American Machinist, No. 45, November 24, p. 593.

The new engineering building of the university of Pennsylvania. (2,400 words & fig.)

Bulletin of the International Railway Congress. (Brussels.)

1906 **625** .251
Bulletin of the Railway Congress, No. 11, November, p. 1647.

FÜHR (A.). — The Kapteyn apparatus for recording continuous brake trials. (2,500 words & fig.)

1906 **621** .335
Bulletin of the Railway Congress, No. 11, November, p. 1657.

HILD (F. W.). — The gasoline car for interurban service. (6,600 words & fig.)

1906 **621** .131.3 & **656** .222.1
Bulletin of the Railway Congress, No. 11, November, p. 1672.

Recent high-speed trials of steam locomotives. (2,900 words & 2 tables.)

1906 **385**. (09.1 (.54)
Bulletin of the Railway Congress, No. 11, November, p. 1679.

BLUM & GIESE (E.). — The passenger service on the Ceylon railways. (2,100 words, 2 tables & fig.)

1906 **656** .23
Bulletin of the Railway Congress, No. 11, November, p. 1685.

Suburban traffic (question XII, 7th session). Discussion. (11,700 words.)

1906 **656** .235
Bulletin of the Railway Congress, No. 11, November, p. 1711.

Slow freight rates (question XIII, 7th session). Discussion. (14,000 words.)

1906 **656** .235 (.54)
Bulletin of the Railway Congress, No. 11, November, p. 1741.

DRING (William A.). — Slow freight rates (question XIII, 7th session). — Note on the freight rates on the Indian railways. — Appendix to the discussion. (3,500 words.)

1906 **54**
ulletin of the Railway Congress, No. 11, November, p. 1748.

The radium controversy. (2,350 words.)

1906 **625** .143.2
ulletin of the Railway Congress, No. 11, November, p. 1751.

Phosphorus in steel rails. (1,700 words.)

1906 **625** .251
ulletin of the Railway Congress, No. 11, November, p. 1754.

Proportioning brake-shoe pressures to wheel loads. ,200 words.)

1906 **656** .261
ulletin of the Railway Congress, No. 11, November, p. 1756.

The express companies. (1,400 words.)

1906 **621** .131.2
ulletin of the Railway Congress, No. 11, November, p. 1758.

Limits for weight on axles. (1,150 words.)

1906 **016** .385. (02
ulletin of the Railway Congress, No. 11, November, p. 107.

Monthly bibliography of railways. — Books. (17 labels).

1906 **016** .385. (05
ulletin of the Railway Congress, No. 11, November, p. 109.

Monthly bibliography of railways. — Periodicals. 66 labels.)

Engineer. (London.)

1906 **624** .8
ngineer, No. 2651, October 19, p. 390.

New swing bridge at Velsen. (1,200 words & fig.)

1906 **725** .32
ngineer, No. 2652, October 26, p. 411.

The new goods station at Newcastle. (3,800 words fig.)

1906 **625** .13 & **625** .4
ngineer, No. 2652, October 26, p. 414.
— No. 2653, November 2, p. 439.

HALDEN (G. M.). — Setting out of tube railways. 3,800 words, 1 table & fig.)

1906 **621** .132.8
ngineer, No. 2652, October 26, p. 432.
— No. 2653, November 2, p. 456.

RICHES (T. H.) & HASLAM (S. B.). — Railway motor ar traffic. (4,500 words, 3 tables & fig.)

1906 **624** .63
ngineer, No. 2653, November 2, p. 442.

Erection of a concrete bridge. (1,100 words & fig.)

1906 **621** .132.3
Engineer, No. 2653, November 2, p. 446.

Prairie type locomotive—Northern Pacific Railroad. (400 words & fig.)

1906 **625** .13
Engineer, No. 2654, November 9, p. 465.

The Channel tunnel project. (2,200 words & fig.)

1906 **625** .251
Engineer, No. 2654, November 9, p. 484.

The Maximus brake. (700 words & fig.)

1906 **621** .13 (.42)
Engineer, No. 2655, November 16, p. 500.
— No. 2656, — 23, p. 518.

Locomotive development on British railways. (4,100 words & tables.)

1906 **621** .132.4
Engineer, No. 2655, November 16, p. 508.

Six-coupled bogie goods engine. (450 words & fig.)

1906 **621** .14
Engineer, No. 2556, November 23, p. 534.

CLARKSON (T.). — Steam as a motive power for public service vehicles. (3,000 words & fig.)

Engineering. (London.)

1906 **656** .257
Engineering, No. 2130, October 26, p. 554.
— No. 2131, November 2, p. 588.

Electrically operated points and signals at Didcot. (3,000 words & fig.)

1906 **621** .132.5
Engineering, No. 2130, October 26, p. 556.

Four-cylinder compound ten-coupled locomotive; Milan exhibition. (1,000 words & fig.)

1906 **621** .336
Engineering, No. 2130, October 26, p. 573.

JENKIN (C. F.). — The advent of single-phase electric traction. (7,700 words.)

1906 **621** .132.8
Engineering, No. 2131, November 2, p. 591.

Steam rail motor-car for the Lancashire & Yorkshire Railway. (500 words & fig.)

1906 **625** .616
Engineering, No. 2132, November 9, p. 632.

Narrow-gauge locomotive at the Milan exhibition. (450 words & fig.)

1906 **621** .132.3
Engineering, No. 2133, November 16, p. 673.

Four-cylinder compound six-coupled locomotive for the Austrian State Railways. (350 words & fig.)

1906 **621** .33
Engineering, No. 2134, November 23, p. 683.

The electrification of the Simplon tunnel. (4,500 words & fig.)

1906 **621** .14
Engineering, No. 2134, November 23, p. 709.

CLARKSON (T.). — Steam as a motive power for public-service vehicles. (5,500 words & fig.)

Engineering Magazine. (London.)

1906 **385**. (07.13
Engineering Magazine, November, p. 169.

BECKER (O. M.). — A modern adaptation of the apprentice-ship system. (3,000 words.)

1906 **621** .7
Engineering Magazine, November, p. 177.

JACOBS (H. W.). — Organization and economy in the railway machine shop. (3,200 words & fig.)

Engineering News. (New York.)

1906 **621** .33 (.73)
Engineering News, No. 19, November 8, p. 467.

Conversion of the Atlantic City Line of the West Jersey & Seashore R. R. Co. (Pennsylvania R. R. System) to electric traction. (5,500 words & fig.)

1906 **625** .113
Engineering News, No. 20, November 15, p. 502.

ROSS (T. A.). — A simplified method of laying out transition curves. (600 words, 1 table & fig.)

1906 **656** .281
Engineering News, No. 20, November 15, p. 514.

Rails and rail-lifts on the thoroughfare draw near Atlantic City, N. J., Newfield branch of West Jersey & Seashore R. R. (1,500 words & fig.)

Great Western Railway Magazine. (London.)

1906 **385** .113 (.42)
Great Western Railway Magazine, November, p. 218.

The Board of Trade Railway returns. (550 words & tables.)

Indian Engineering. (Calcutta.)

1906 **624** .32
Indian Engineering, No. 18, November 3, p. 286.

STONEY (E. W.). — The new Chittravate bridge, Madras Railway. (2,300 words & fig.)

Journal of the Franklin Institute. (Philadelphia.)

1906 **621** .133.7
Journal of the Franklin Institute, No. 4, October, p. 279.

KNEASS (S. L.). — High pressure steam tests of an injector. (2,500 words & fig.)

Locomotive Firemen's Magazine. (Indianapolis.)

1906 **625** .253
Locomotive Firemen's Magazine, November, p. 622.

Westinghouse compound air pumps. (2,200 words, 1 table & fig.)

1906 **621** .133.7
Locomotive Firemen's Magazine, November, p. 629.

The modern locomotive injector. (2,800 words, 4 tables & fig.)

Locomotive Journal. (Leeds.)

1906 **625** .13
Locomotive Journal, No. 11, November, p. 533.

The construction of a new bridge under an existing railway. (2,700 words & fig.)

Locomotive Magazine. (London.)

1906 **621** .132.8
Locomotive Magazine, No. 171, November 15, p. 184.

Steam rail motor coaches. (700 words & fig.)

Page's Weekly. (London.)

1906 **621** .14
Page's Weekly, No. 115, November 23, p. 1139.

CLARKSON (T.). — Steam as a motive power for public service vehicles. (2,400 words & fig.)

Proceedings of the Institution of Civil Engineers. (London.)

1905-06 **656** .211.7
Proceedings of the Inst. of Civil Eng., vol. CLXV, p^{t} III, p. 87.

WEBSTER (J. J.). — The Widnes and Runcorn transporter-bridge. (22,000 words, tables & fig.)

1905-06 **624** .1
Proceedings of the Inst. of Civil Eng., vol. CLXV, pt III, p. 219.

ESLING (F. K.). — A problem relating to railway-bridge piers of masonry of brickwork. (2,700 words, 3 tables & fig.)

1905-06 **624** .2
Proceedings of the Inst. of Civil Eng., vol. CLXV, pt III, p. 231.

BOYCOTT (G. W. M.). — Caisson-disease at the New High-Level bridge, Newcastle-on-Tyne. (2,000 words, 1 table & fig.)

Railroad Gazette. (New York.)

1906 **621** .132.8 (.42)
Railroad Gazette, No. 15, October 12, p. 310.

Rail-motor-car traffic in England. (2,600 words, 1 table & fig.)

1906 **621** .132.5
Railroad Gazette, No. 15, October 12, p. 315.

Mallet compound locomotive for the Great Northern. (1,700 words & fig.)

1906 **621** .133.1
Railroad Gazette, No. 16, October 19, p. 335.

BEMENT (A.). — Testing coal. (3,300 words.)

1906 **625** .235
Railroad Gazette, No. 16, October 19, p. 342.

Steel passenger cars built by the Pressed Steel Car Company. (700 words & fig.)

1906 **621** .132 (.73)
Railroad Gazette, No. 16, October 19, p. 344.

FOWLER (G. L.). — The development of American freight locomotives. (2,200 words & fig.)

1906 **656** .212.6
Railroad Gazette, No. 17, October 26, p. 356.

Hullett car dumping machine. (800 words & fig.)

1906 **656** .253
Railroad Gazette, No. 17, October 26, p. 368.

A comprehensive signaling scheme. (500 words & fig.)

1906 **625** .13
Railroad Gazette, No. 18, November 2, p. 380.

The Pennsylvania tunnels Across Manhattan Island. (1,500 words & fig.)

1906 **621** .132.5
Railroad Gazette, No. 18, November 2, p. 389.

Mallet compounds for the Erie. (250 words & fig.)

1906 **625** .245
Railroad Gazette, No. 18, November 2, p. 390.

Track inspection car on the Baltimore & Ohio. (1,200 words & fig.)

1906 **625** .236
Railroad Gazette, No. 18, November 2, p. 392.

FLORY (B. F.). — Car cleaning. (1,600 words & fig.)

1906 **656** .222.1 (.73)
Railroad Gazette, No. 18, November 2, p. 394.

Records of fast runs. (500 words & 1 table.)

1906 **621** .132.3
Railroad Gazette, No. 19, November 9, p. 406.

Heavy Pacific type locomotive for the Northern Pacific. (1,500 words & fig.)

1906 **621** .132.4
Railroad Gazette, No. 19, November 9, p. 414.

Balanced compound Prairie type locomotives for the Atchison, Topeka & Santa Fe. (500 words & fig.)

1906 **621** .33 (.73)
Railroad Gazette, No. 19, November 9, p. 415.

Electrification of the West Jersey & Seashore. (1,800 words & fig.)

1906 **621** .138.2
Railroad Gazette, No. 20, November 16, p. 435.

Anthracite coal storage. (500 words & fig.)

1906 **621** .132.8
Railroad Gazette, No. 20, November 16, p. 437.

Union Pacific motor car No. 8. (150 words & fig.)

Railway Age. (Chicago.)

1906 **621** .132.5
Railway Age, No. 1585, October 26, p. 514.

Heavy consolidation locomotive for the Delaware & Hudson. (600 words & fig.)

1906 **621** .33 (.73)
Railway Age, No. 1587, November 9, p. 572.

Electrical equipment of the West Jersey & Seashore branch of the Pennsylvania Railroad. (3,800 words & fig.)

1906 **621** .132.3
Railway Age, No. 1587, November 9, p. 582.

Four-cylinder compound Pacific locomotive for the Northern Pacific. (1,200 words & fig.)

1906 **625** .245
Railway Age, No. 1587, November 9, p. 589.

A car for transportation of live poultry. (200 words & fig.)

1906 **625** .13
Railway Age, No. 1588, November 16, p. 609.

Railway tunnels to Manhattan Island. (2,500 words & fig.)

Railway Engineer. (London.)

1906 **656** .255
Railway Engineer, No. 322, November, p. 347.

Union Switch & Signal Co's new train staff. (1,200 words & fig.)

Railway and Engineering Review. (Chicago.)

1906 **621** .331
Railway and Engineering Review, No. 41, October 13, p. 794.

Contracting for hydro-electric power on railways. 2,300 words & fig.)

1906 **621** .132.4
Railway and Engineering Review, No. 44, November 3, p. 848.

Heavy Prairie type locomotive, A. T. & S. F. Ry. (400 words & fig.)

1906 **621** .7
Railway and Engineering Review, No. 44, November 3, p. 851.

Inspection of materials for railway equipment during process of manufacture and construction, and its advantages. (2,200 words & fig.)

1906 **625** .154
Railway and Engineering Review, No. 44, November 3, p. 853.

GREENLEAF (C. A.). — Evolution of the railway turntable. (700 words & fig.)

1906 **625** .151 & **656** .257
Railway and Engineering Review, No. 46, November 17, p. 890.

New signals for facing-point switches on the Harriman lines. (250 words & fig.)

1906 **621** .132.3
Railway and Engineering Review, No. 46, November 17, p. 894.

40,000th locomotive built by the American locomotive Co. (800 words & fig.)

1906 **625** .144. (01
Railway and Engineering Review, No. 46, November 17, p. 895.

Maintaining track for the tonnage and speed of today. 2,400 words & fig.)

Railway Gazette. (London.)

1906 **621** .32 & **625** .233
Railway Gazette, No. 17, October 26, p. 454.

The Vickers-hall system of electric train lighting. 800 words & fig.)

1906 **621** .132.8
Railway Gazette, No. 17, October 26, p. 456.

Rail motor car, Isle of Wight Central Railway. (500 words & fig.)

1906 **621** .132.5
Railway Gazette, No. 17, October 26, p. 463.

Mallet compound locomotive for the Great Northern. (1,700 words & fig.)

1906 **625** .232
Railway Gazette, No. 18, November 2, p. 485.

New corridor trains, Great Eastern Railway. (350 words & fig.)

1906 **625** .235
Railway Gazette, No. 18, November 2, p. 490.

Steel passenger cars built by the Pressed Steel Car Company. (700 words & fig.)

1906 **621** .132 (.73)
Railway Gazette, No. 18, November 2, p. 492.

FOWLER (G. L.). — The development of American freight locomotives. (2,200 words & fig.)

1906 **656** .253
Railway Gazette, No. 19, November 9, p. 516.

A comprehensive signaling scheme. (500 words & fig.)

1906 **621** .336
Railway Gazette, No. 20, November 16, p. 530.

JENKIN (C. F.). — Single-phase electric traction. (2,600 words & fig.)

1906 **656** .255
Railway Gazette, No. 20, November 16, p. 533.

Improvements in signalling on single lines. (1,100 words & fig.)

1906 **625** .236
Railway Gazette, No. 20, November 16, p. 540.

FLORY (B. F.). — Car cleaning. (1,600 words & fig.)

1906 **656** .222.1 (.73)
Railway Gazette, No. 20, November 16, p. 542.

Records of fast runs. (500 words & 1 table.)

1906 **621** .132.8
Railway Gazette, No. 21, November 23, p. 557.

Condensing in steam-electric locomotives. (500 words & fig.)

1906 **621** .33 (.73)
Railway Gazette, No. 21, November 23, p. 563.

Electrification of the West Jersey & Seashore. (1,500 words & fig.)

Railway and Locomotive Engineering. (New York.)

1906 **624** .63

Railway and Locomotive Engineering, November, p. 491.

Concrete viaduct. (700 words & fig.)

Railway Machinery. (New York.)

1906 **621** .131.2

Railway Machinery, November, p. 116.

FOWLER (G. L.) & MELLIN (C. J.). — The designing of a locomotive. (1,600 words & fig.)

Railway Magazine. (London.)

1906 **385**. (09.1 (.42)

Railway Magazine, No. 113, November, p. 393.

SEKON (G. A.). — Illustrated interview. (4,800 words, 1 table & fig.)

1906 **656** .211.5

Railway Magazine, No. 113, November, p. 416.

New train departure indicator at Liverpool street terminus. (800 words & fig.)

1906 **621** .132.1 (.42) & **656** .222.1 (.42)

Railway Magazine, No. 113, November, p. 460.

ROUS-MARTEN (C.). — British locomotive practice and performance. (3,500 words & fig.)

Railway Maintenance and Structures. (New York.)

1906 **625** .142.3

Railway Maintenance and Structures, November, p. 227.

PORTER (H. T.). — Experience with steel ties on the Bessemer & Lake Erie R. R. (2,100 words.)

Railway Master Mechanic. (Chicago.)

1906 **621** .7

Railway Master Mechanic, No. 11, November, p. 357.

Angus shops. Canadian Pacific Railway. (3,200 words & fig.)

1906 **621** .135.1

Railway Master Mechanic. No. 11, November, p. 377.

Welding broken locomotive frames by the thermit process—Central Railroad of New Jersey. (700 words & fig.)

Railway Times. (London.)

1906 **621** .33 & **625** .4

Railway Times, No. 19, November 10, p. 473.

The Great Northern Piccadilly and Brompton Railway. (2,500 words & fig.)

1906 **621** .132.8

Railway Times, No. 21, November 24, p. 521.

South Western Railway motor car development. (300 words & fig.)

South African Railway Magazine. (Johannesburg.)

1906 **656** .28 (01

South African Railway Magazine, No. 3, November, p. 136.

MOORE (W.). — Minor railway accidents. (2,100 words & fig.)

Street Railway Journal. (New York.)

1906 **621** .336

Street Railway Journal, No. 18, November 3, p. 870.

Experimental three-wire system in Vienna. (2,000 words & fig.)

1906 **621** .331

Street Railway Journal, No. 18, November 3, p. 875.

Sub-stations and transmission system of the New York Central & Hudson River Railroad. (2,200 words & fig,)

1906 **621** .33

Street Railway Journal, No. 19, November 10, p. 928.

The electrical equipment of the West Jersey & Seashore Branch of the Pennsylvania Railroad. (6,600 words, tables & fig.)

1906 **625** .215

Street Railway Journal, No. 19, November 10, p. 947.

FOWLER (G. L.). — Tables of car positions on curves. (250 words & tables.)

Tramway & Railway World. (London.)

1906 **621** .33 (09.1 & **625** .61 (.42)

Tramway & Railway World, November, p. 433.

Burton and Ashby light railways. (4,000 words &- fig.)

In Italian.

Giornale del genio civile. (Roma.)

1906 **621** .33 (.45)

Giornale del genio civile, settembre, p. 505.

Ancora delle ferrovie elettriche Valtellinesi. (3,600 parole.)

1906 **625** .216

Giornale del genio civile, settembre, p. 513.

Apparecchio Pavia-Casalis per l'agganciamento automatico dei carri ferroviari. (2,400 parole & fig.)

1906 **656** .234

Giornale del genio civile, settembre, p. 517.

La tariffa differenziale per i viaggiatori. (900 parole & 2 tavole.)

Ingegneria ferroviaria. (Roma.)

1906 **621** .33 & **656** .27

Ingegneria ferroviaria, nº 21, 1º novembre, p. 350.

Le automotrici benzoelettriche delle ferrovie ungheresi. (1,500 parole, 2 tavole & fig).

1906 **625**. 1

Ingegneria ferroviaria, nº 22, 16 novembre, p. 357.

FERRARIO (C.). — Pro spluga. (6,300 parole.)

1906 **621** .132.3 (.45)

Ingegneria ferroviaria, nº 22, 16 novembre, p. 366.

Locomotiva compound a 4 cilindri gruppu 6 4 0 delle ferrovie dello Stato. (1,800 parole & fig.)

1906 **621** .336

Ingegneria ferroviaria, nº 22, 16 novembre, p. 369.

La terza rotaia delle ferrovie Varesine. (750 parole, 1 tavole & fig.)

Rivista generale delle ferrovie e dei lavori pubblici. (Firenze.)

1906 **621** .33

Rivista generale delle ferrovie, nº 46, 11 novembre, p. 723.

LANINO (P.). — Considerazioni intorno all' applicazione della trazione elettrica alle linee di valico. (3,400 parole.)

1906 **721** .4 (01

Rivista generale delle ferrovie, nº 47, 18 novembre, p. 738.

Esame critico delle formule in uso per il calcolo delle volte. (1,800 parole.)

In Dutch.

Ingenieur. ('s Gravenhage.)

1906 **621** .116

Ingenieur, nr 46, 17 November, p. 855.

DE KUYSER (J.). — Automatische stookinrichtingen. (4,500 woorden, 1 tafereel & fig.)

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BULLETIN

OF THE

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ASSOCIATION

(ENGLISH EDITION)

[**621** .132.5 (.489)]

THE FOUR-CYLINDER EXPRESS LOCOMOTIVES OF THE DANISH STATE RAILWAY,

By O. BUSSE,

LOCOMOTIVE AND ROLLING STOCK SUPERINTENDENT, DANISH STATE RAILWAY.

Figs. 1 to 15, pp. 145 to 149.

The steady growth in the traffic, and the continual increase in the weight of trains, due to the improved carriage accommodation given, make it necessary to use heavier locomotives, giving more than 1,000 horse-power. With this object in view, the track has been stiffened by putting in rails weighing 45 kilograms per metre (90·71 lb. per yard). A four-cylinder compound on the Vauclain system, of the Atlantic type, was selected; it has very simple valve-gear and the St. Louis trials showed that the steam consumption was moderate.

The probable wear of the tires, determined according to the method described in a note published by me in the *Bulletin of the Railway Congress*, March, 1904, page 183, led to the decision that the high-pressure cylinders should act on the leading pair of driving wheels and the low-pressure cylinders on the trailing pair; the pistons on each side acting in opposite directions, the variations in the wheel-loads are so small that the locomotive may be expected to run over 100,000 kilometres (62,000 miles) before it is necessary to turn up the tires again.

The locomotive has a bar-frame; this type has been recognized as superior, in America as well in the case of the recent locomotives of the Bavarian State Railway, owing to the reduced weight and the ease of access to the different parts of the mechanism. The other dimensions being the same, the water evaporated is 9,390 kilograms (20,700 lb.) per hour in the case of the bar-frame locomotive; in that of the plate-frame locomotive with narrow fire-box, it does not exceed 8,340 kilograms (18,387 lb.) per hour.

The fire-box of the boiler is very broad at the bottom. The water space measures 100 millimetres (3 $^{15}/_{16}$ inches) across at the narrowest point, and becomes wider higher up; this arrangement will materially lengthen the life of the fire-box stays. The back wall slopes forwards, so as to protect the crew against the effects of radiation. In order to facilitate the firing and improve the distribution of air over the large grate, two fire-doors are provided. The deflector or rather the two deflectors are supported on a vertical block standing on the grate, and rest on two projections screwed to the sides of the fire-box by studs and nuts.

The fire-box has a single row of rivets (see *Bulletin of the Railway Congress*, September, 1906, page 1345); the expansion blocks have bronze slides resting on the-bar frame; the stays are 90 to 100 millim. (3 $^9/_{16}$ to 4 inches) apart and the front rows are of adjustable length (see *Bulletin of the Railway Congress*, January, 1904, page 44).

In order that sufficient air may reach the grate (*see* for my opinion *Bulletin of the Railway Congress*, August, 1904, page 864), the ashpan consists of one middle and two side boxes, each with two dampers placed one above the other, which are operated together and allow sufficient air to reach the grate.

The barrel of the boiler consists of two rings; the front ring is cylindrical, the other is taper, its diameter increasing by 120 millimetres (4 $^{11}/_{16}$ inches). This makes a better arrangement of the tubes possible. The centres of the tubes are 70 millimetres (2 $^3/_4$ inches) apart; this gives a 19 millimetres ($^3/_4$ inch) space for the circulation of the water.

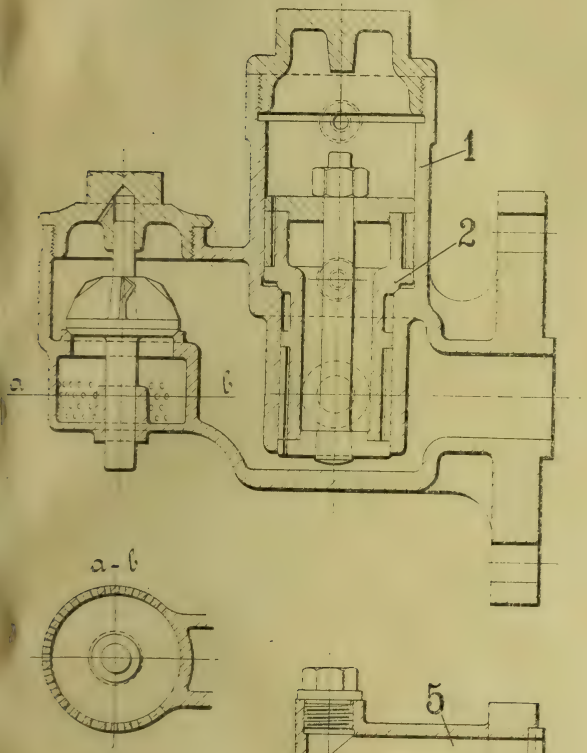
The starting valve (figs. 1 to 3) is fixed to the valve chest so that opening 6 communicates with the steampipe between the boiler and the slide valve, whereas openings 4 and 5 communicate with the passages leading from the slide valve to the front and back of the high-pressure piston. It consists of a vertical cylinder 1, in which piston 2 is acted on, on its lower side, by the pressure in the slide valve and on its upper side by the pressure in the boiler. If the steam from the boiler is cut off by means of a cock placed in the cab and communicating with opening 3, then piston 2 goes up and steam enters through the passages 4 and 5 to the two sides of the high-pressure piston and through the intermediate receiver to the low-pressure piston. The engine is thus driven by the latter only until, after part of a revolution, all the cylinders work in their normal way. The same cock which controls the starting valve has a second set of openings through which steam passes to little pistons which can open the blow-off cocks.

The cross-heads are arranged so that thin pieces of metal can be inserted between the body of the cross-heads and the bronze slide-blocks, so as to adjust the latter when they become worn; the piston rod is thus always in a line with the centre of the stuffing box, a condition absolutely necessary when metal packing is used.

Our locomotive also differs from the American locomotives on the Vauclain system in being fitted with Walschaerts valve gear, designed so that the steam to the high-pressure cylinder can be cut off at 82 per cent. The outside lap of the high-pressure slide valve is 24 millimetres ($^{15}/_{16}$ inch) and the arms of the advance lever are designed for a lead of 3 millimetres ($^1/_8$ inch).

The volume diagram for a high-pressure cut-off at 30 per cent, was based on these figures, and the other laps were designed so that with this cut-off, which is most frequently used, there is as little loss of pressure as possible while the steam passes to the intermediate receiver. The inside lap of the high-pressure slide valve is accordingly —3 millimetres (—$^1/_8$ inch) and of the low-pressure slide valve —8 millimetres (—$^5/_{16}$ inch); the outside lap of the latter is +20 millimetres (+$^{25}/_{32}$ inch).

Fig. 1.



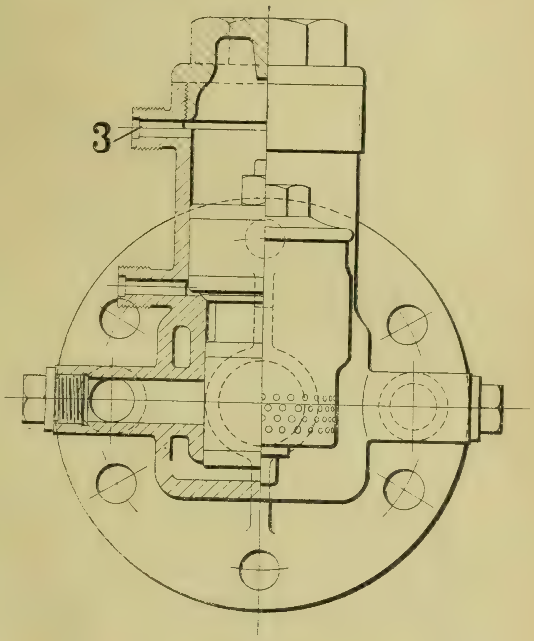


Fig. 3.

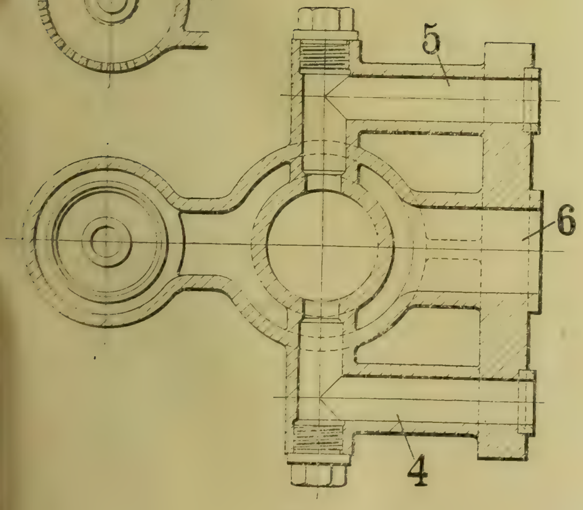


Fig. 2.

As the connecting rods operated by the high and low-pressure cylinders are not o the same length it is not possible, as it generally is, to have quite the same cut-off forwards and backwards in both high-pressure and low-pressure cylinders. The cut-off in the high-pressure cylinders is the same forwards as backwards, but in the low-pressure cylinders the release is adjusted to correspond to opposite positions of the cranks.

A model of the valve gear was made and examined, and the lap was finally adjusted as follows :

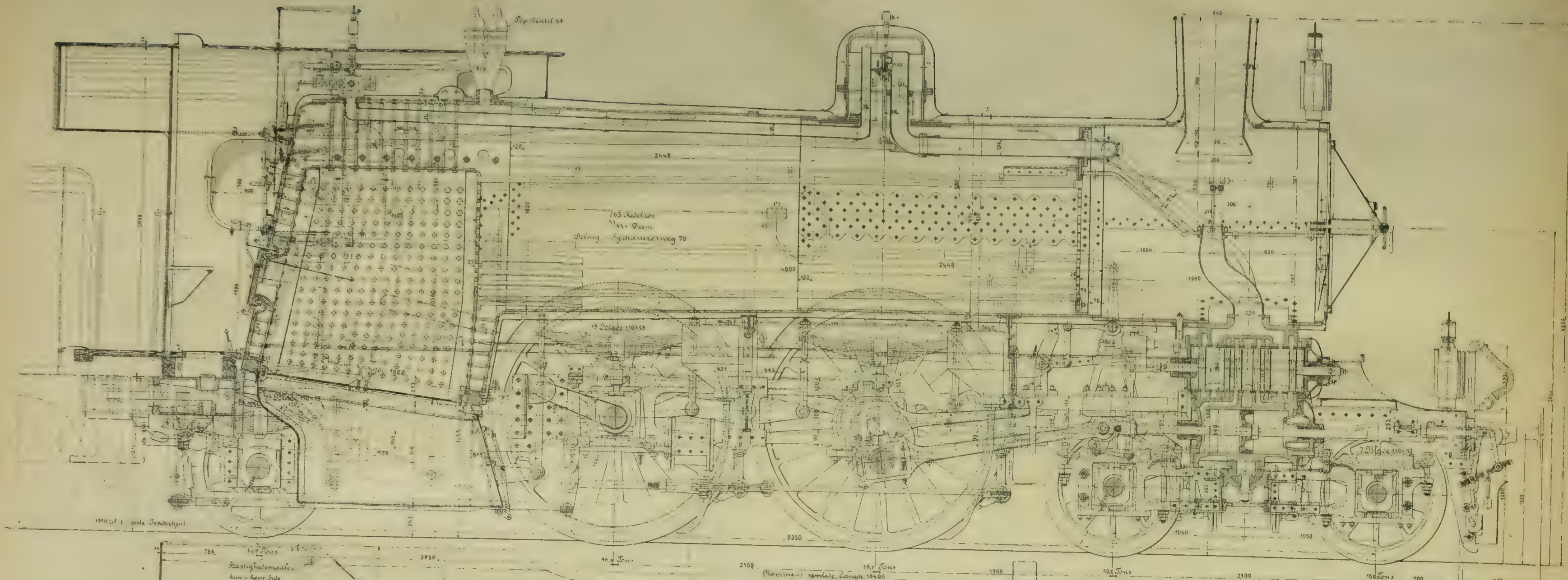
Outside lap, high pressure, front and back . . .	+ 24 millimetres	$(+\ ^{15}/_{16}$ inch).
— low — — — . . .	+ 20 —	$(+\ ^{25}/_{32}$ —).
Inside lap, high pressure,	front	— 4 —	$(-\ ^{5}/_{32}$ —).
	back.	— 3 —	$(-\ ^{1}/_{8}$ —).
— low —	front	— 10 —	$(-\ ^{25}/_{64}$ —).
	back.	— 6 —	$(-\ ^{15}/_{64}$ —).

The experiments made on the model gave the following figures :

CUT-OFF.	GREATEST OPENING.		ADMISSION.				RELEASE.				STROKE OF SLIDE VALVE.
			Start.		End.		Start.		End.		
	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	
P. C.	MILLIM.	MILLIM.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	
High-pressure cylinder.											
Max.	33 $(1\ ^{19}/_{64}'')$	33 $(1\ ^{19}/_{64}'')$	0 08	0·08	81·7	84·8	93·2	94·2	96·3	95·8	120
50.	12 5 $(^{1}/_{2}'')$	10·5 $(^{13}/_{32}'')$	0·37	0·42	50·2	50·3	79·0	79·8	86·8	86·2	71
30.	6 $(^{15}/_{64}'')$	5·5 $(^{7}/_{32}'')$	0·83	0 83	30·5	28·3	67·8	67·0	77·5	76·0	61
0.	3 $(^{1}/_{8}'')$	3 $(^{1}/_{8}'')$	5·92	4·82	6·7	6·5	45·0	42·5	54·7	57·2	54
Max. . . .	33 $(1\ ^{19}/_{64}'')$	33 $(1\ ^{19}/_{64}'')$	0·17	0·17	78 8	84·7	92 3	94·0	96·2	95·2	117
Low-pressure cylinder.											
Max.	37 $(1\ ^{29}/_{64}'')$	37 $(1\ ^{29}/_{64}'')$	0·29	0·42	84	87	91·5	91·7	97·2	97·7	120
50.	14·5 $(^{37}/_{64}'')$	16·5 $(^{21}/_{32}'')$	1·33	1·83	52	62·8	73	75·3	91·2	91·3	71
30.	9·5 $(^{3}/_{8}'')$	10 $(^{25}/_{64}'')$	3·0	4·0	32·3	44·8	58	62·5	84·2	84·2	61
0.	7 $(^{9}/_{32}'')$	7 $(^{9}/_{32}'')$	10·0	15·82	11·5	16·5	33·7	36·8	67·0	63·3	54
Max.	37 $(1\ ^{29}/_{64}'')$	37 $(1\ ^{29}/_{64}'')$	0·33	0·50	83·3	85·0	91·3	90·5	96·8	97·5	117

Lead : high-pressure slide, 3 millimetres ($^{1}/_{8}$ inch); low-pressure slide, 7 millimetres ($^{9}/_{32}$ inch).

Fig. 4.



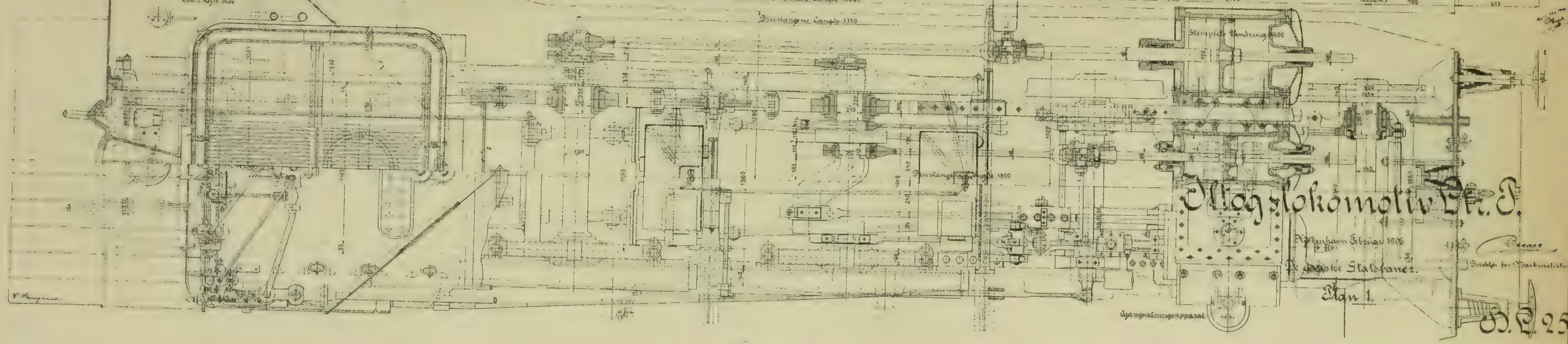
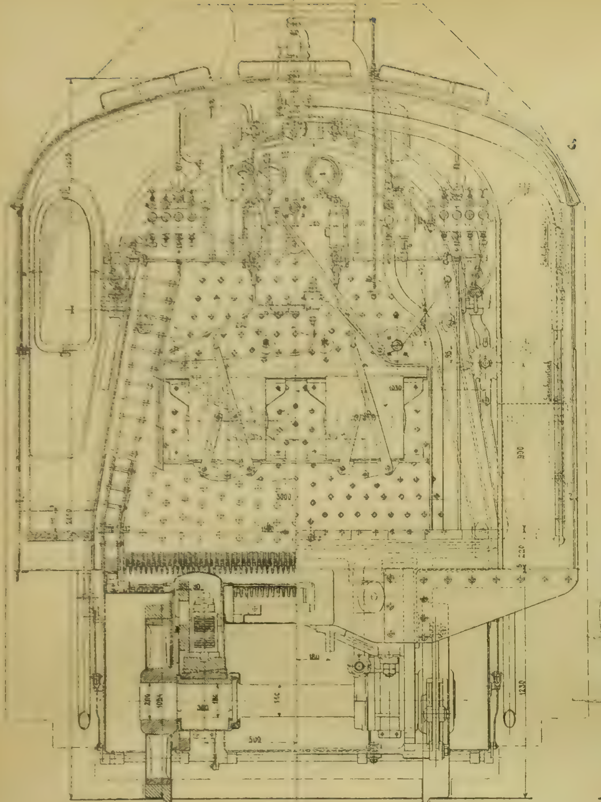
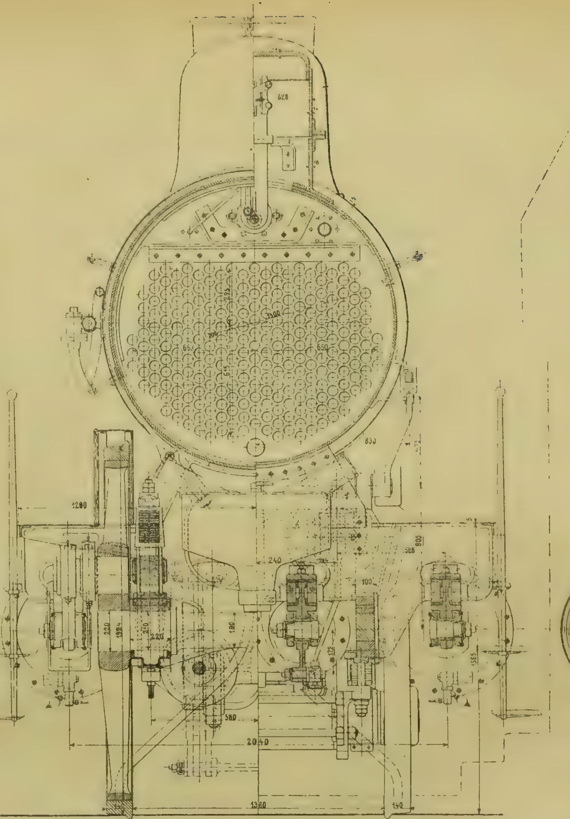
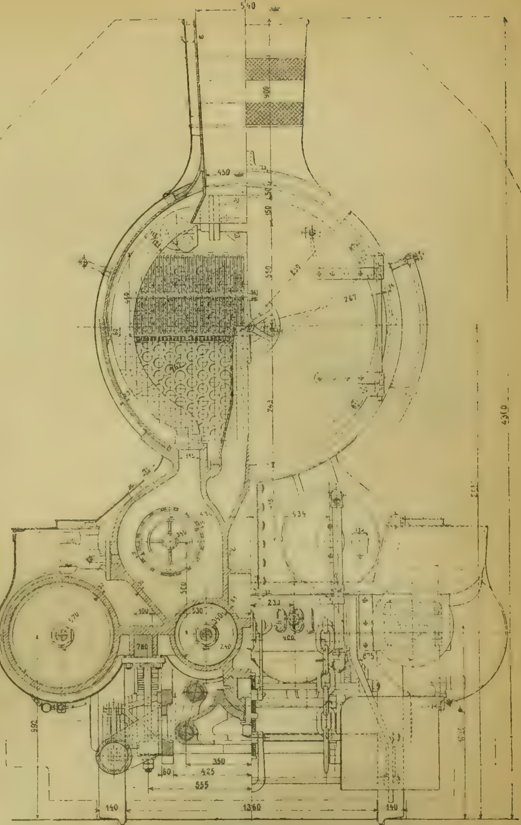


Fig. 5.

Figs. 4 and 5.







Befordret Togvægt i Tons (eksklusive Loko og Tender).

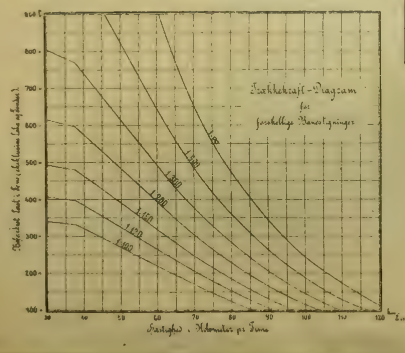
Togart	HE	E	K	HI	I
Grundhastighed i km	100	90	86	80	70
Middelhastighed paa forskellige Strækninger	91/95	81/85	72/78	68/72	61/68
Togvægt	210	260	350	370/400	370/400

De mindre Middelhastigheder gælde Strækn. mellem Nyborg & [illegible]
" større " " Kjøbenhavn Korsør

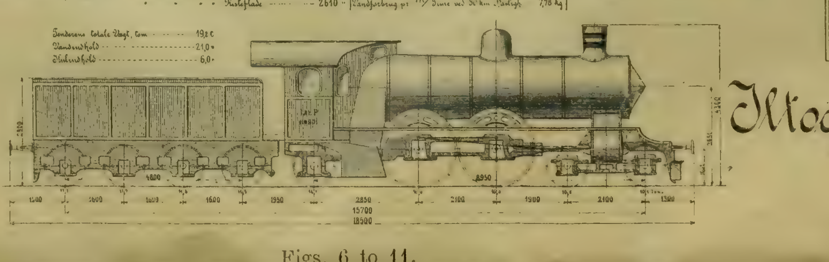
Hedepaavirkningsflade i Rørene (Antal 263, Længde 4300 mm, Diam. 45/51 mm, Deling 70 mm)	192,4 m²
Hedepaavirkningsflade i Fyrkassen	12,1 "
Total do	204,5 "
Risteflade total	3,23 "
Kedeltryk p =	15 kg/cm²
Vandfordampning ved 100 mm Vakuum	8430 kg
Vand fordampet p. m² Hedepaavirkningsflade	41,2 "
" " " Risteflade	2610 "

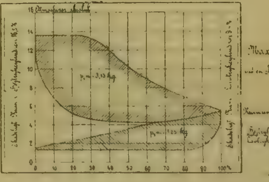
Diameter af lille Cylinder	$d_1 =$	340 mm
" " store "	$d_2 =$	570 "
Stempelslag	$l =$	600 "
Drivhjulsdiameter	$D =$	1984 "
Største Middeltryk i lille Cylinder	0,56 p =	8,4 kg/cm²
" " " store "	0,36 p =	5,4 "
Største Trækkraft $\frac{l(8,4 d_1^2 + 5,4 d_2^2)}{D}$		8200 kg
Indic. HK ved 90 km Hastighed		1083
Vandforbrug pr HK/Time ved 90 km Hastigh.		7,78 kg

Total Vægt, tom	59,8 t
Vægt af Vand i Kedlen	5,7 "
Total Vægt, tjenstfærdig	67,1 "
Vægt af Truck med Hjul	5,0 "
Vægt af forreste Drivhjul med Aksler, Belastning, Akselkasser, Fjedre etc.	4,65 "
Vægt af bageste Drivhjul med do do	4,27 "
" " Løbehjul med do do	1,80 "



Tenderens totale Vægt, tom 19,2 t
Vandindhold 21,0 "
Kulindhold 6,0 "





Max. Dampdiagram ved en Hastighed af 30 km/Time

Kammer Volumen 126% af Højtrykcyl.

$\frac{\text{Højtrykcylinderens Volumen}}{\text{Lavtrykcylinderens Volumen}} = \frac{1}{2,8}$

Iltogslokomotiv Litr. P.

Kjøbenhavn Februar 1906.

Busse
Direktør for Maskinafdelingen

De danske Statsbaner

Plan 2

Figs. 6 to 11.

Fig. 12.

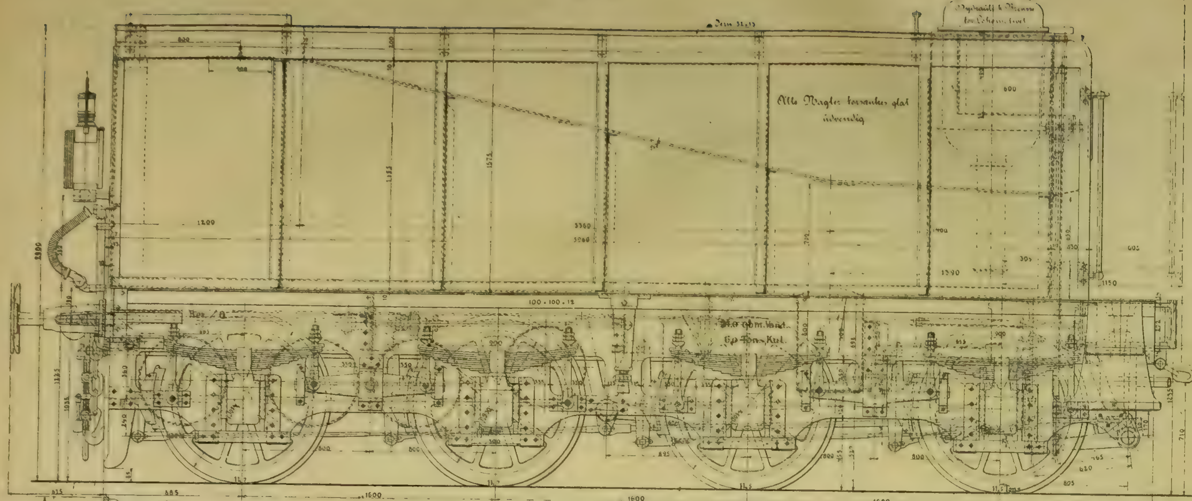
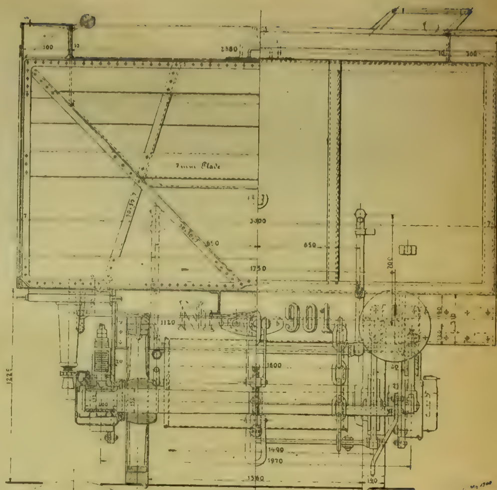

Alle Nagler forsænket glat indvendig
100 · 100 · 12
1200
3360
3060
1600
1950 til Lokomotivets bageste Trykhjul

Fig. 13.



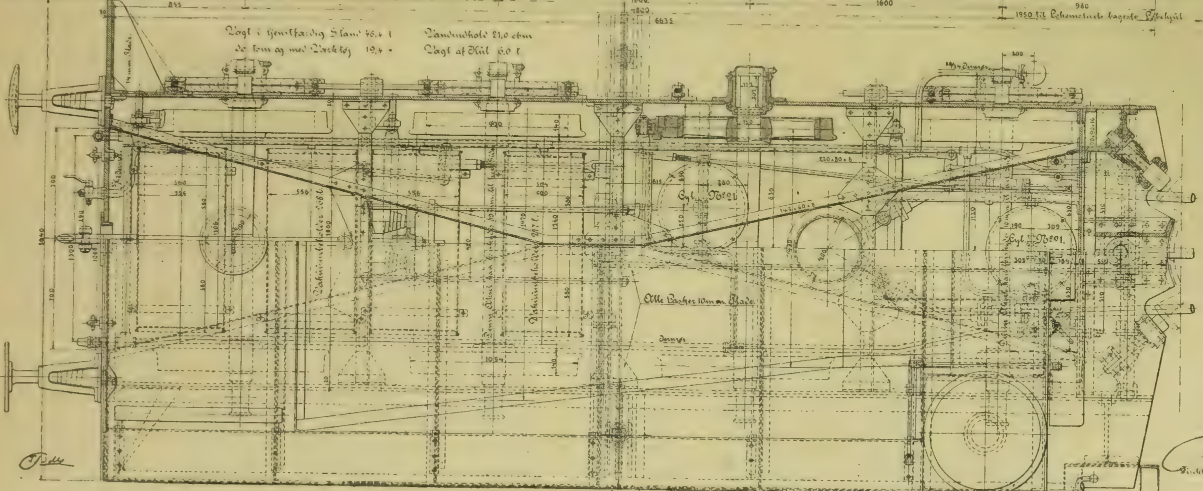


Fig. 14.

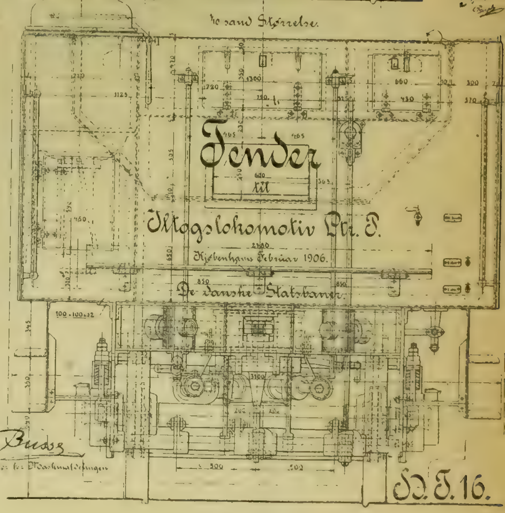


Fig. 15.

Figs. 12 to 15.

Although the reciprocating masses balance each other to a large extent, the wheels have counterbalance weights equal to 25 per cent of the excess. At a speed of 100 kilometres (62·1 miles) per hour, the variation in the wheel pressure, of the driving and coupled wheels, is ± 830 kilograms (1,830 lb.).

The four axle-boxes of the driving wheels are in two pieces, as on all Danish locomotives (see *Eisenbahn-Maschinenwesen der Gegenwart*, 1903 edition, p. 226).

The cab is fixed to the boiler so that when the latter expands it moves with it; where connected with the foot plate expansion blocks and openings are provided so as not to interfere with the free movement of the cab.

The trailing carrying axle has a lateral play of 15 millimetres ($^{19}/_{32}$ inch) with wedge check. All the axle-boxes are designed so that it is easy to remove the cover plates in order to renew the lubricating pads.

The tenders are not on bogies, but have four separate axles; the first and third have a lateral play of 20 and 10 millimetres ($^{25}/_{32}$ and $^{25}/_{64}$ inch) respectively.

This design has been preferred to the bogies generally used, because it is much simpler and lighter; moreover, the running is smoother than it would be with bogie centres close together. Trials made with this arrangement of axles, proposed by Gölsdorf, show that even with locomotives having a wheelbase of 5·6 metres (18 ft. 4 $^{1}/_{2}$ in.) the tires become worn very little in spite of the sharp curves (radius 180 metres [9 chains]) found on Austrian railways. The frame is built as usual of plate 20 millimetres ($^{25}/_{32}$ inch) thick, and the water tank is of the trough shape usual on the Danish State Railway, enclosing the space for the coal supply. But the water is fed in, on the very noteworthy Gölsdorf system, through two openings in the side of the tender.

The locomotive and tender are fitted with the automatic vacuum brake, but as it was also desired to brake the bogie and there was no room under the locomotive for the vacuum cylinders necessary for the driving wheels and the bogie wheels, a device was fitted on the tender by which the vacuum cylinder produces a hydraulic pressure of 12 kilograms per square centimetre (170·67 lb. per square inch) which is transmitted by thin and flexible tubes to the brake cylinders.

Chief dimensiens.

Diameter of high-pressure cylinders. .	(d_1)	340	millimetres	(1 ft. 1 $^{3}/_{8}$ in.).
— of low-pressure — . .	(d_2)	570	—	(1 ft. 10 $^{7}/_{16}$ in.).
Length of stroke.	(l)	600	—	(1 ft. 11 $^{5}/_{8}$ in.).
Diameter of driving wheels	(D)	1,984	—	(6 ft. 6 $^{1}/_{8}$ in.).
— of bogie, carrying and tender wheels.		1,054	—	(3 ft. 5 $^{1}/_{2}$ in.).
Total wheelbase of locomotive		8,950	—	(29 ft. 4 $^{5}/_{8}$ in.).
Rigid — —		2,100	—	(6 ft. 10 $^{11}/_{16}$ in.).
Heating surface, fire-box	(Hf)	12·1	square metres	(130·25 square feet).
— tubes	(Hr)	192·4	—	(2,071·05 —).
— total	(H)	204·5	—	(2,201·30 —).
Grate area.	(R)	3·23	—	(34·77 —).

Ratio H : R	63·2.
Heating surface per ton of weight in working condition	3·05 sq. metres (33·36 sq. feet per Engl. ton).
Working pressure . . . (*p*)	15 atmospheres (220·59 lb. per square inch.)
Inside diameter of barrel	1,620 to 1,500 millimetres (5 ft. 3 $^{3}/_{4}$ in. to 4 ft. 11 in.).
Length of tubes between tube-plates	4,800 millimetres (15 ft. 9 in.).
Diameters of tubes	45·5 and 51 — (1 $^{25}/_{32}$ inch and 2 inches)
Distance between centres of tubes	70 — (2 $^{3}/_{4}$ inches).
Number of tubes	263.
Height of centre line of boiler above rails	2,650 millimetres (8 ft. 8 $^{3}/_{8}$ in.).
— of the chimney above rails	4,300 — (14 ft. 1 $^{5}/_{16}$ in.).
Weight, adhesive	32 tonnes (31·5 English tons).
— total, in working condition	67·1 — (66 —).
— of water in boiler	6·7 — (6·6 —).
— of locomotive, empty	59·8 — (58·9 —).
Maximum mean pressure in H. P. cylinder $= 0.56p$ . . . =	8·4 atmospheres (123·53 lb. per square inch).
Maximum mean pressure in L. P. cylinder $= 0.36p$ . . . =	5·4 — (79·41 — —).
Tractive effort, maximum $\frac{l\,(8\cdot 4d_1^2 + 5\cdot 4d_2^2)}{D} =$	8,200 kilog. (18,078 lb.).
— per square meter of heating surface	40 — (8·19 lb. per square foot).
— per ton of weight in working condition	122 — (273 lb. per English ton).
— per ton of adhesive weight	256 — (573 — —).

Tender.

Water	21 tonnes (4,620 English gallons).
Coal	6 — (5·9 English tons).
Weight loaded	46·2 — (45·5 —).
Total wheelbase	4,800 millimetres (15 ft. 9 in.)
Rigid —	3,200 — (10 ft. 6 in.)

[531 :87]

NOTE ON THE WORKING LOOSE OF NUTS,

By André MINNE,

CIVIL ENGINEER, JUVISY-SUR-ORGE (SEINE-ET-OISE).

Fig. 1, p. 154.

(*Mémoires et compte rendu des travaux de la Société des ingénieurs civils de France*, July. 1906.)

The troubles, difficulties and even dangers which result from the working loose of nuts are well known.

A large number of remedies have been and are still being proposed.

Many are very ingenious, but most of them are too complicated for ordinary use. The simplest, and those most extensively used, are the ordinary lock-nut, the split-pin and the Grover washer.

These systems, often very useful, are nevertheless not satisfactory in many cases, the reason being that they do not attack the real cause of the working loose of the nut. This cause lies in the mass of the nut, or rather in its inertia; it often happens that the complex vibrations to which the constituent parts of a machine are subjected, produce in the nuts which hold the machine together, resultants or rather couples which tend to turn back those nuts.

It has been observed on some high speed motors that under the action of vibration nuts have left their seat and travelled several threads up the shanks of their bolts. It is evident that the movement of these unrestrained nuts up the shanks could only be the result of their mass relatively to the bolt and of the couples in question.

We can calculate that the *vis viva* acquired by a nut under such conditions is proportional to the thickness of the nut, and varies with the fourth power of its outside diameter.

Let us assume the nut to be a cylindrical ring of mass M having outside and inside diameters D and d and that the unscrewing couple acts on the mean cylinder and produces a velocity V proportional to its diameter $\frac{D - d}{2}$; we then find that the energy imparted by the action of a vibration is given by

$$\frac{1}{2} MV^2 = \alpha D^4 + \dots\dots$$

Therefore the ordinary lock-nut, which consists of a second nut of the same diameter as the first, cannot act as a certain lock, for it is itself subjected to vibration under very much the same conditions as the nut proper, and there is nothing to prevent it from working loose first.

On the other hand, take the principle of the lock-nut; it acts by forcing its lower thread against the upper thread of the nut proper, and this is the real original and ingenious point about it. But it must be recognized that the shape the lock-nut generally has, only enables it to utilize a very small proportion of its possible useful effect.

For its lower surface is flat to the circumference of the circle inscribed in the hexagon; and the whole of this face is in contact with the corresponding upper face of the nut. Consequently, only a small part of the force used forces the threads together; the rest makes the two faces stick together, so that the two nuts will often act as one, the two working loose together, one dragging along the other.

Another effect profuced by the contact of the two nuts has often been observed, but misinterpreted. The pressure of the lock-nut on the nut must overcome the reaction of the threads of the latter on the threads of the bolt, and finish by pressing the nut against its seat, eliminating the adhesion between the threads of the nut and bolt. Thus the nut becomes useless, and may be considered as loose on the shank, as the reactions in question, increased by those produced by tightening the lock-nut, are transferred to the threads of the latter, which then becomes the nut proper. Some designers have even considered it advisable to have the lock-nuts thicker than the nuts proper.

The true principle of the lock-nut has thus not been recognized, and hence lock-nuts are often unsatisfactory. In such cases, a split-pin is often added. The latter is used either alone, inserted in a hole drilled through the shank, or together with some other device, *e g.*, the castellated nut. But the split-pin system has the disadvantage of preventing any accuracy in the tightening; there is the expense of drilling the holes, of supplying the split-pins which it is difficult to put in or take out; the latter are often sheared off by the nuts, or become broken or rusted in. In fact the whole system is as inconvenient as it is uncertain.

We have still to consider the Grover washer, which has been used very extensively; its great merits are its simplicity, the ease with which it is used, and its inexpensiveness. Its disadvantages are that the accuracy of the nut is lost, for the tightening effected depends on the elasticity of a steel spring; moreover, the flat surfaces in contact (which it is often found advisable to increase by interposing a flat washer) are eliminated and replaced by a narrow and skew surface which produces, when the tightening is effected, an oblique and quite defective reaction in the threads and the shank of the bolt.

The Grover washer is hardly used in mechanisms proper; its main application, due to its very low price, has been in the case of fishplate bolts where it must be admitted that it has done valuable service, although it has proved insufficient at important points and on track appliances, the majority of the railways use the ordinary lock-nut for such purposes.

Thus after all, we return to the ordinary lock-nut; none of the systems tried have such simplicity, convenience and accuracy.

The defects mentioned have to be removed in order to gat lock-nuts of real efficiency; this has been done in the lock-nut we have worked out, which is based on the two following principles :

1° Reduction of the surfaces in contact, so that only those parts of the faces, of the nut and lock-nut, which are bounded by the diameter of the thread, are in contact. Then when the lock-nut is tightened, the two threads are forced together and there is no objectionable adhesion between the corresponding faces.

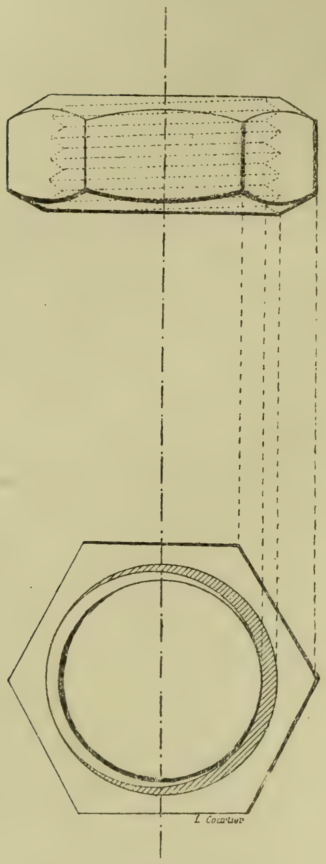


Fig. 1.

This at the same time prevents any pressure of the lock-nut on the nut, which alone has to stand the reaction of the parts held together, the only action of the lock-nut being to prevent loosening;

2° Reduction of the diameter of the lock-nut to a minimum, so that less energy is imparted by the vibrations to the lock-nut than to the nut proper; the latter then in turning back forces the threads in contact more tightly together.

A lock-nut designed on these principles, is shown in figure 1; the plan and elevation show the surface in contact with the nut proper, this surface being reduced to the diameter of the outside of the thread. The theoretical considerations quoted above have been fully confirmed by the applications made, from October, 1902, onwards, to the rolling stock and permanent way of several railway and tramway companies, to motor cars, and to many other machines subjected to violent vibration; nuts which formerly frequently worked loose have been definitely fixed by lock-nuts of this type.

The system has been extensively applied during the last four years; among the more important applications giving the most searching test, from the railway point of view, we may mention :

1° Locomotives and rolling stock.

On the French State Railway, a first trial was made on the stays of the horn plates of an American locomotive; the nuts formerly frequently worked loose, but now remain permanently fast. This trial lasted one whole year and then some hundred applications were made; as a result, the system is now generally adopted, and such nuts are specified in *lieu* of all ordinary lock-nuts, particularly in the case of hangers for locomotives, tenders and carriages.

2° Permanent way.

The Paris Metropolitan made a first trial of 500 of these lock-nuts for fishbolts.

Subsequently, several thousands of these lock-nuts were used at particular points; finally they have been adopted generally on all curves, loops, track appliances, treadles of electric signals.

It thus certainly seems that this type of lock-nut satisfies the conditions of the problem : to lock the nuts proper by a simple, inexpensive appliance which can be used anywhere on any bolt; easy to apply or take off; making it possible to adjust the tightening with all desired accuracy, and to take up any play; and completely safe.

[621 .33]

THE ELECTRIC RAILWAYS AND TRAMWAYS OF SWITZERLAND,

By W. A. MÜLLER,
CIVIL ENGINEER.

Figs. 1 to 3, pp. 156 and 167.

(*Elektrische Bahnen und Betriebe.*)

Switzerland has developed its railway systems very extensively. This is particularly true of its electric lines; the length, now open to traffic, of such lines already amounts to 15·8 per cent of the total length of the Swiss railways (as against 6·8 per cent in Germany). There are two principal reasons for this : the great number of tourists and the great water power available among the mountains. A large number of the electric railways could never have been built, had it not been for the tourist traffic. Moreover, the comparatively low cost of electric energy makes it possible to use electric traction (that is to say the only form of traction that can be used in many cases, such as tramways and railways with steep gradients), when steam traction railways with rack and independent roadbed, or with extra-long lines to avoid steep gradients, would not have earned interest for the large amount of capital expenditure required. If we compare the length of the electric railways of Switzerland (738 kilometres [459 miles]) with that of Germany (3,791 kilometres [2,356 miles]), in 1904, we find that per 100,000 inhabitants there are 21·5 kilometres (13·4 miles) in Switzerland as against 6·4 kilometres (4 miles) in Germany; and that per 1,000 square kilometres of area, there are 17·8 kilometres (28·6 miles per 1,000 square miles) in Switzerland as against 7 kilometres (11·3 miles per 1,000 square miles) in Germany. (Switzerland has 3,425,383 inhabitants and an area of 41,324 square kilometres [15,956 square miles]; Germany 59,495,000 inhabitants and an area of 540,743 square kilometres [208,790 square miles]. Thus there are, per square kilometre of area, 83 inhabitants [215 inhabitants per square mile] in Switzerland and 110 [285 inhabitants per square mile] in Germany.)

The total length open to traffic, of all the Swiss electric railways, was 674 kilometres (419 miles) in 1903 and 738 kilometres (459 miles) in 1904. The corresponding figures for Germany are 3,692 kilometres (2,294 miles) in 1903 and 3,791 kilometres (2,356 miles) in 1904. Figures 1 and 2 show, graphically, the development of the electric system since 1894. The steam tramways are not given in figure 1; in 1894 there were still 9 kilometres (5·6 miles) so operated, but by 1902 none were left. The length, open to traffic, of the Swiss railways, as shown in figure 2, is the total single length of all the railways, including those worked by foreign companies, counting the double lines as single lines and not including the length in foreign countries. (We may here mention that the first standard gauge railway in Switzerland was opened in 1844, the first tramway in 1862, the first rack railway in 1871, the first narrow gauge steam railway in 1873 and the first cable railway in 1877. The first electric line was probably the Vevey-Chillon tramway opened in 1888.)

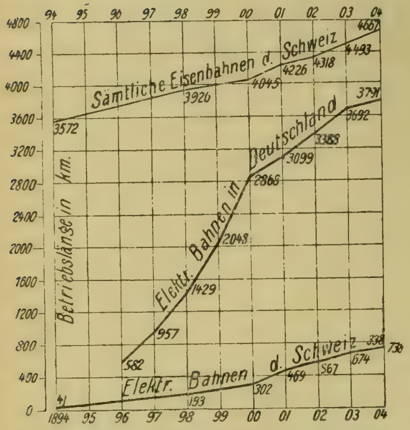


Fig. 1. — Electric railways in Germany and Switzerland.

Explanation of German terms : Betriebslänge in km. = Length open. — Sämtliche Eisenbahnen d. Schweiz = Total railways, Switzerland. — Elektr. Bahnen in Deutschland = Electric lines, Germany.— Elektr. Bahnen d. Schweiz = Electric lines, Switzerland.

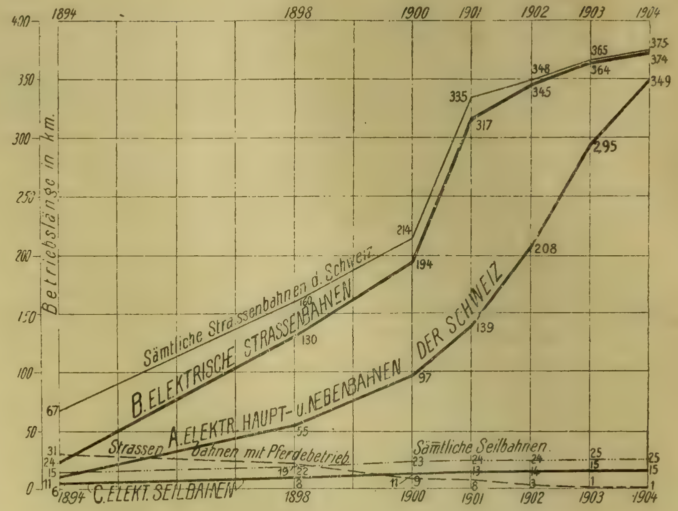


Fig. 2. — Electric lines in Switzerland.

Explanation of German terms : Sämtliche Strassenbahnen d. Schweiz = Total tramways, Switzerland. — B. Elektrische Strassenbahnen = Electric tramways. — A. Elekt. Haupt- u. Nebenbahnen der Schweiz = Electric main and secondary railways, Switzerland. — Strassenbahnen mit Pferdebetrieb = Tramways, horse traction. — C. Elekt. Seilbahnen = Electric cable railways. — Sämtliche Seilbahnen = Total cable railways.

The sixty-four electric lines include two main lines (length operated, 73 kilometres [45 miles]), eighteen secondary lines, including the rack railways (222 kilometres [138 miles]), twenty-nine tramways (364 kilometres [226 miles]) and fifteen cable railways (15 kilometres [9·3 miles]). Table I, compiled from the official statistics of the Swiss railways for 1903 (¹), gives the chief particulars of all the Swiss electric lines.

Before we consider the results of operating the electric railways and their peculiarities, it will be convenient to give brief particulars about each line from the electro-technical point of view. In the summary given below, the number after the name of the line is the year in which it was opened to traffic; R is the radius of the sharpest curve in metres, V the speed in kilometres per hour, and *n* the number of revolutions of the motors of the vehicles.

A. — Main and secondary lines.

1. *Main line Burgdorf-Thun*, 1899 (²). — Three-phase current, working pressure 750 volts. (Three-phase current at 16,000 volts from Kander generating station; transmitted 47 kilometres

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(¹) This year was selected because the statistics for 1904 were not yet available.

(²) See *Bulletin du Congrès des chemins de fer*, No. 9, September 1900 (1st part), p. 6230, and *Bulletin of the Railway Congress*, No. 8, October 1905, p. 2215.

[29·2 miles]; fourteen transformer substations along the line.) Two wires 8 millimetres (0·315 inch) in diameter, wooden poles (in the station iron poles), bow collectors. Cars with four axles (32 tons) and four motors of 60 horse-power each. $n = 600$. $V = 36$ (22·4 miles) on gradients of 25 per mil). $R = 250$ (12 $^1/_2$ chains).

2. *Main line Freiburg-Murten-Ins*, 1898. — Continuous current, 750 volts. (Three-phase current at 8,000 volts supplied by the State power station of the canton Freiburg, two transformer substations.) Third rail, weight 23 kilograms per metre (46·37 lb. per yard), in the stations, by order of the authorities, overhead conductor only; shoes aud bow collectors. Motor cars with four axles (33 tons) and two motors of 150 horse-power each. $n = 450$. $V = 23$ (14·3 miles) (on gradients of 30 per mil) to 35 (21·7 miles). $R = 250$ (12 $^1/_2$ chains).

3. *Standard-gauge line Orbe-Chavornay*, 1894. — Continuous current, 600 volts. (Own power station.) Overhead conductor, wooden poles, trolley. Motor cars with two axles (12 tons) and two motors of 20 horse-power each. $R = 150$ (7 $^1/_2$ chains).

4. *Secondary line Aarau-Schöftland*, 1901. — Continuous current, 550 volts. (Three-phase current at 25,000 from Beznau power station.) Two wires 8 millimetres (0·315 inch) in diameter, wooden poles with brackets, in the stations tubular poles and lattice poles; bow collectors. Cars with four axles (13 tons) and two motors of 26 horse-power each (maximum power, 2 × 40 horse-power). $V = 25$ (15·5 miles). $R = 30$ (1 $^1/_2$ chain).

5. *Aigle-Leysin*, 1900. — Continuous current, 600 volts. (Generated as three-phase current at 5,500 volts.) 1·97 kilometre (1·22 mile) of adhesion railway (100 per mil) and 4·81 kilometres (2·99 miles) of rack railway (Abt rack, 230 per mil). Overhead conductor, trolley. Motor cars with two axles (15 tons) and two motors of 100 horse-power each. $n = 550$. $V = 7$ to 25 (4·3 to 15·5 miles). $R = 18$ and 60 respectively ($^9/_{10}$ chain and 3 chains respectively).

6. *Bex-Gryon-Villars*, 1898. — Continuous current, 650 volts. (Own power station.) 7·6 kilometres (4·7 miles) of adhesion railway (57 per mil) and 4·8 kilometres (3 miles) of rack railway (200 per mil, Abt rack). 9 millimetre (0·354 inch) wire, trolley. Locomotives with two axles (15 tons) and two motors of 100 horse-power each; motor cars with two axles (7·5 tons) and two motors of 24 horse-power each; cars with four axles and two motors of 35 horse-power each, both motors being on leading bogie. $V = 8$ to 25 (5 to 15·5 miles). $R = 25$ (1 $^1/_4$ chain).

7. *Bremgarten-Dietikon*, 1902. — Continuous current, 700 volts. (Own power station.) Two wires 8 millimetres (0·315 inch) in diameter, wooden poles, trolley. Motor cars with two axles (10 tons) and two motors of 35 horse-power each. $n = 430$. $V = 13$ (8·1 miles). $R = 25$ (1 $^1/_4$ chain).

8. *Châtel-Bulle-Montbovon*, 1903. — Continuous current, 500 volts. (Own power station.) Overhead conductor, wooden poles. Motor cars with four axles (20 tons) and four motors of 30 horse-power each. $R = 90$ (4 $^1/_2$ chains).

9. *Châtel-Palézieux*, 1901. — Continuous current, 500 volts. (Current supplied by last company.) Overhead conductor, wooden poles. Cars with four axles (22 tons) and four motors of 35 horse-power each. $R = 100$ (5 chains).

10. *Geneva-Veyrier*, 1887. — Continuous current, 500 volts. (Own power station.) Two wires 11 millimetres (0·433 inch) in diameter, wooden poles, trolley. Cars with two axles and two motors of 30 horse-power each. R = 40 (2 chains).

11. *Grütschalp-Mürren*, 1891. — Continuous current, 550 volts. (Own power station.) Overhead conductor, wooden poles. Cars with two axles (7 tons) and two motors of 60 horse-power each. R = 50 (2 $^1/_2$ chains).

12. *Lausanne-Moudon and Savigny*, 1902. — Continuous current, 750 volts. (Three-phase current at 8,000 volts supplied by the state power station of the canton Freiburg, two transformer substations.) Two wires 8·25 millimetres (0·3248 inch) in diameter, wooden poles, trolley. Cars with four axles (13 tons) and four motors of 25 horse-power each. n = 360. V = 12 to 35 (7·5 to 21·7 miles). R = 50 (2 $^1/_2$ chains).

13. *Montreux-Berner Oberland*, 1901-1904. — Continuous current, 750 volts. (Three-phase current at 8,000 volts, supplied by Montbovon power station; four substations.) Two wires 8 millimetres (0·315 inch) in diameter, wooden poles; in the stations, iron poles; bow collectors. Motor cars with four axles (24·5 tons) and four motors of 65 horse-power each. V = 15 to 40 (9·3 to 24·9 miles). R = 40 (2 chains). The whole line from Montreux to Zweisimmen, 63 kilometres (39·1 miles) long, was finally opened to traffic on July 6, 1905. Trains of 48 to 90 tons are run with two electric motor cars; one motor man to each car; ammeters show each employee the position of the controller on the other car.

14. *St. Gallen-Speicher-Trogen*, 1903. — Continuous current, 800 volts. (Three-phase current at 10,000 volts from Kubel power station.) In St. Gallen itself only 500 volts are used. Two wires 8 millimetres (0·315 inch) in diameter, wooden poles; in the city tubular poles; trolley. Cars with four axles (15 tons) and four motors of 25 horse-power each. V = 13 to 25 (8·1 to 15·5 miles). R = 25 (1 $^1/_4$ chain).

15. *Sissach-Gelterkinden*, 1891. — Continuous current, 700 volts. (Own power station.) Wire 6 millimetres (0·236 inch) in diameter, wooden poles, trolley. Locomotives with two axles (6·2 tons) and two motors of 25 horse-power each. R = 50 (2 $^1/_2$ chains).

16. *Stanstad-Engelberg*, 1898 (¹). — Three-phase current, 750 volts. (Own power station, generating three-phase current at 750 volts, which is partly transformed into current at 3,500 volts, then reduced to current at 750 volts at the substations along the line.) 21 kilometres (13 miles) of adhesion railway and 1·5 kilometres (0·93 mile) of rack railway. Two wires 7·5 millimetres (0·2953 inch) in diameter, wooden poles, bow collectors. Motor cars with four axles (14 tons) and two motors of 35 horse-power each (n = 480), on the leading bogie. On the steep gradients ("ladder" rack) the cars are pushed up, without being coupled up, by locomotives with two axles and two motors of 75 horse-power each (n = 650). V = 5 to 20 (3·1 to 12·4 miles). R = 50 (2 $^1/_2$ chains).

17. *Vevey-Chamby*, 1902. — Continuous current. (Own power station.) Overhead conductor, wooden poles. Cars with two axles and two motors, and cars with four axles and four motors. R = 60 (3 chains).

(¹) See *Bulletin of the Railway Congress*, No. 5, May, 1899, p. 698, and *Bulletin du Congrès des chemins de fer*, No. 9, September 1900 (1st part), p. 6228.

18. *Wetzikon-Meilen,* 1903. — Continuous current, 750 volts. (Three-phase current at 25,000 from Beznau power station.) Wire 8 millimetres (0·315 inch) in diameter, wooden poles, trolley. Cars with four axles (14 tons) and four motors of 25 horse-power each. R = 25 (1 1/4 chain).

19. *Gornergrat*, 1898 (1). — Three-phase current, 500 volts. (Own power station generating three-phase current at 5,400 volts.) Mountain railway with rack, with Abt flat teeth. Terminus at a height of 3,020 metres (9,908 feet). Two wires 8 millimetres (0·315 inch) in diameter, wooden pooles, trolley. Rack locomotive with two axles (10·5 tons) and two motors of 90 horse-power each ($n = 800$). Car combined with locomotive, the latter forming a bogie of the car. V = 7 (4·3 miles). R = 80 (4 chains).

20. *Jungfrau* (2). — Three-phase current, 500 volts. (Own power station, generating three-phase current at 7,000 volts, transformer substations along line.) Mountain railway, Strub rack. Two wires of 9 millimetres (0·354 inch) in diameter, wooden pooles; in the tunnels, hangers; poles and sliding contacts. Locomotive with two axles (No. 6, 16·8 tons) and two motors of 150 horse-power each. $n = 760$. V = 8·1 (5·03 miles). R = 100 (5 chains). On July 26, 1905, the line was opened up to the Eismeer station (height 3,156 metres [10,355 feet]); length 5·7 kilometres (3·5 miles).

B. — **Tramways.**

21. *Allaman-Aubonne-Gimel*, 1896. — Continuous current, 600 volts. (Own power station.) Overhead conductor, trolley. Cars with two axles and two motors of 55 horse-power each. R = 40 (2 chains).

22. *Altstätten-Berneck*, 1897. — Continuous current, 600 volts. (Own power station.) Wire 8 millimetres (0·315 inch) in diameter, wooden poles, trolley. Cars with two axles (6·5 tons) and one motor of 18 horse-power. R = 125 (6 1/4 chains).

23. *Bale tramways*, 1895. — Continuous current, 550 volts. (Own power station.) Two wires 8 millimetres (0·315 inch) in diameter; wall plates; in places lattice poles. Cars with two axles (6·9 tons) and two motors of 20 horse-power each; ($n = 900$); and cars with two axles (5 tons) and one motor of 15 horse-power. R = 10 (1/2 chain).

24. *Birseck tramway*, 1902. — Continuous current, 550 volts. (Own power station.) Two wires 8 millimetres (0·315 inch) in diameter, wooden poles, bow collectors. Cars with two axles and two motors of 30 horse-power each. V = 40 (24·9 miles). R = 25 (1 1/4 chain).

25. *Berne tramways*, 1890. — Continuous current, 500 volts. (Own power station, generating three-phase current.) Wire 8 millimetres (0·315 inch) in diameter, wall plates, tubular poles, lattice poles; bow collectors. Cars with four axles (12 tons) and two motors of 35 horse-power each ($n = 500$); and cars with two axles (8·5 tons) and two motors of 20 horse-power each ($n = 500$). R = 30 (1 1/2 chain).

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(1) See *Bulletin of the Railway Congress*, No. 5, May 1899, p. 669, and *Bulletin du Congrès des chemins de fer*, No. 9, September 1900 (1st part), p. 6224.

(2) See *Bulletin of the Railway Congress*, No. 5, May, 1897, p. 726, and No. 9, September 1897, p. 1283, and *Bulletin du Congrès des chemins de fer*, No. 9, September 1900 (1st part), p. 6225.

26. *Biel tramways*, 1877. — Continuous current, 550 volts. (Three-phase current at 2,000 volts, supplied by Hagneck power station.) Wire 8 millimetres (0·315 inch) in diameter, tubular poles and lattice poles; bow collectors. Cars with two axles and two motors of 15 horse-power each. R = 22 (1 $^1/_{10}$ chain).

27. *Chaux-de-Fonds tramway*, 1897. — Continuous current, 550 volts. (Supply, continuous current at 1,400 volts.) One wire, tubular poles, bow. Cars with two axles and two motors of 25 horse-power each. R = 20 (1 chain).

28. *Dolder tramway*, 1899. — Continuous current. (Power station jointly with Dolder cable railway.) R = 20 (1 chain).

29. *Freiburg tramways*, 1897. — Continuous current, 550 volts. (Current supplied by Hauterive power station.) Wire 8 millimetres (0·315 inch) in diameter, wall plates, trolley. Cars with two axles and two motors of 20 horse-power each. On gradients of 101·7 per mil, grip-brakes and deals along the side of the rails. R = 25 (1 $^1/_4$ chain).

30. *Lausanne tramways*, 1896. — Continuous current, 550 volts. (Own power station.) Two wires (in places only one) 8 to 10 millimetres (0·315 to 0·394 inch) in diameter, wooden poles, tubular poles, lattice poles. Grip-brakes and deals along the rails on the 127 per mil gradient.

31. *Limmattal tramway*, 1900. — Continuous current, 500 volts (Supplied as three-phase current at 2,000 volts by the Zurich municipal power station.) Wire 5 millimetres (0·197 inch) in diameter, wooden poles, trolley. Cars with two axles and two motors of 20 horse-power each. V = 30 (18·6 miles). R = 25 (1 $^1/_4$ chain). Mail trailer cars 1·4 metres (4 ft. 7 in.) high, 1·6 metres (5 ft. 3 in.) long, and with a wheelbase of 1 metre (3 ft. 3 $^3/_8$ in.).

32. *Lugano tramway*, 1896. — Three-phase current, 400 volts. (Municipal power station, three-phase current at 5,000 volts.) Overhead conductor, tubular poles, trolley. Cars with two axles and one motor of 20 horse-power. V = 30 (18·6 miles). R = 20 (1 chain).

33. *Lucerne tramways*, 1899. — Continuous current, 575 volts. (Supplied as three-phase.) Two wires 8 millimetres (0·315 inch) in diameter, wall plates, tubular poles and lattice poles, trolley. Cars with two axles (7·2 tons) and two motors of 20 horse-power each. R = 20 (1 chain).

34. *Neuchatel tramways*, 1892. — Continuous current, 580 volts. (Own power station.) Two wires (over a section only one) 9 millimetres (0·354 inch) in diameter, wall plates, tubular poles, lattice poles, wooden poles, trolley. Cars with four axles (15 tons) and two motors of 40 horse-power each; and cars with two axles and two motors of 18 horse-power each. Grip-brakes and deals along the rails on the 86 per mil gradients. R = 27 (1·35 chain).

35. *Riffelalp tramway*, 1899. — Continuous current (bought). Overhead conductor. One motor car only, with ten seats. R = 30 (1 $^1/_2$ chain).

36. *Rolle-Grimel*, 1898. — Continuous current, 650 volts. (Own power station.) One wire, wall plates, wooden poles, trolley. Cars with two axles and one motor of 25 horse-power. R = 20 (1 chain).

37. *St. Gallen tramway*, 1897. — Continuous current, 550 volts. (Own power station.) At first bow collectors, later on trolley, two wires 8 millimetres (0·315 inch) in diameter (without

overhead switches); return by the rails, on some sections by special naked copper wires. Tubular poles. Cars with two axles (9·5 tons) and two motors of 40 horse-power each. V = 10 to 20 (6·2 to 12·4 miles). R = 15 ($^3/_4$ chain).

38. *St. Moritz tramway*, 1896. — Continuous current. (Own power station.) Overhead conductor, trolley. R = 30 (1 $^1/_2$ chain).

39. *Schaffhausen tramway*, 1901. — Continuous current, 550 volts. (Own power station; three-phase current at 2,000 volts generated.) One wire 8 millimetres (0·315 inch) in diameter, wall plates, tubular poles, trolley. Cars with two axles and two motors of 24 horse-power each. R = 20 (1 chain).

40. *Schwyz-Seewen*, 1900. — Three-phase current, 550 volts. (Supplied as three-phase current at 8,000 volts.) Two wires 8 millimetres (0·315 inch) in diameter, wall plates, wooden poles, trolley. Cars with two axles (9·5 tons) and two motors of 25 horse-power each. $n = 400$. R = 100 (5 chains).

41. *Geneva tramways*, 1862 to 1902. — Continuous current, 500 volts. (Own power station.) Two wires 8 millimetres (0·315 inch) in diameter, tubular poles and wooden poles, trolley and U shaped slippers. Cars with two axles (8·5 tons) and two motors of 18 horse-power each; cars with four axles and two motors of 25 (and 30) horse-power each. R = 20 (1 chain).

42. *Val-de-Ruz*, 1903. — Continuous current, 650 volts. (Three-phase current at 8,000 volts supplied by Hagneck power station.) Two (in places one) wires 8 millimetres (0·315 inch) in diameter, wall plates, wooden poles, trolley. Cars with two axles and two motors of 30 horse-power each. V = 12 to 23 (7·5 to 14·3 miles). R = 250 (12 $^1/_2$ chains).

43. *Vevey-Chillon*, 1888 (rack section, 1898). Continuous current, 450 volts. (Own power station.) Siemens conductors, two copper tubes with slot underneath for collector. Cars with two axles (3·6 to 4·5 tons) and one motor of 25 horse-power. 0·6 kilometre (0·37 mile), from Trait to Planches (gradient, 150 per mil), with rack; rack fixed to one running rail. Return by second conductor. R = 35 (1 $^3/_4$ chain).

44. *Chillon-Villeneuve*, 1903. — Continuous current, supplied by contract. Overhead conductor. R = 40 (2 chains).

45. *Winterthur-Töss*, 1898. — Continuous current at 550 volts (bought). Wire 8 millimetres (0·315 inch) in diameter, tubular poles, bows. Cars with two axles and two motors of 15 horse-power each. R = 20 (1 chain).

46. *Zurichberg power station line*, 1895. — Continuous current, 500 volts. (Own power station.) One wire, trolley. Cars with two axles and two motors of 14 horse-power each. V = 9 to 15 (5·5 to 9·3 miles). R = 12 ($^3/_5$ chain). (Line taken over in 1905 by the Zurich municipal tramway.)

47. *Zurich tramways*, 1882 to 1900. — Continuous current, 550 volts. (Own power station; partly three-phase current at 2,000 volts.) Two wires 8 millimetres (0·315 inch) in diameter. Wall plates, tubular poles, trolley. Cars with two axles and two motors of 24 horse-power each. V = 12 to 18 (7·5 to 11·2 miles). R = 18 ($^9/_{10}$ chain).

48. *Zurich-Höngg*, 1898. — Continuous current at 550 volts (bought). Two wires 8 millimetres (0·315 inch) in diameter, wall plates, tubular poles. R = 180 (9 chains).

49. *Zurich-Oerlikon-Seebach*, 1897. — Continuous current, 550 volts. (Own power station.) Two (in places one) wires 8 millimetres (0·315 inch) in diameter, wall plates, wooden poles, tubular poles, trolley. Cars with two axles (7 tons) and two motors of 25 horse-power each. V = 12 to 25 (7·5 to 15·5 miles). R = 25 (1 1/4 chain).

C. — **Cable lines.** (1)

50. *Biel-Leubringen*, 1898. — Continuous current. V = 7·2 (4·5 miles). R = 200 (10 chains).

51. *Burgenstock*, 1888. — Continuous current. V = 4·07 (2·53 miles). R = 320 (16 chains) (at passing places, 140 [7 chains]). With rack.

52. *Davos-Schatzalp*, 1899. — Continuous current. V = 4·5 (2·8 miles). R = 300 (15 chains).

53. *Dolder line*, 1895. — Continuous current. V = 10·08 (6·3 miles). R = 120 (6 chains).

54. *Gurten line*, 1899. — Three-phase current. V = 7·2 (4·5 miles). R = 600 (30 chains) (at passing places, 250 [12 1/2 chains]). Current bought.

55. *Kriens-Sonnenberg*, 1892. — Continuous current. R = 150 (7 1/2 chains).

56. *Lausanne-Signal*, 1899. — Continuous current (up to 1900, driven direct by petrol motors). V = 7·2 (4·5 miles). R = 600 (30 chains) (at passing places, 250 [12 1/2 chains]).

57. *Lauterbrunnen-Grütschalp*, 1891. — Continuous current (up to 1902, hydraulic power). V = 45 (2·8 miles). R = 1,000 (50 chains).

58. *Reichenbach line*, 1899. — Continuous current. V = 7·2 (4·5 miles). R = 150 (7 1/2 chains).

59. *Salvatore line*, 1890. — Three-phase current. V = 3·6 (2·2 miles). R = 300 (15 chains).

60. *St. Imier-Sonnenberg*, 1903. — Continuous current. R = 300 (15 chains).

61. *Stanserhorn line*, 1893. — Continuous current. In three sections, carriages changed twice. V = 3·6 to 7·2 (2·2 to 4·5 miles). R = 120 (6 chains).

62. *Vevey-Pelerin*, 1900. — Continuous current. V = 5·4 (3·4 miles). R = 275 (13 3/4 chains).

63. *Zurichberg line*, 1889. — Continuous current (bought). V = 5·15 (3·2 miles). R = 100 (5 chains). Rack.

64. *Zurich-Rigiviertel*, 1901. — Continuous current (bought). R = 120 (6 chains).

64 kilometres (40 miles) more were added in 1904 to these sixty-four lines which have a total length of 674 kilometres (419 miles).

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(1) All the cable lines, except 54, 63 and 64, have their own power stations.

New electric lines opened in 1904.

A. — MAIN AND SECONDARY LINES.

	Length.
Montreux-Berner Oberland, 2nd section, Montbovon-Gstaad	23·8 kilometres (14·8 miles).
Wynental line	22·3 — (13·8 —).
Saint-Légier-Châtel-Saint-Denis	7·6 — (4·7 —).

B. — TRAMWAYS.

Bale tramways, extension.	1·9 kilometres (1·2 miles).
Hauts-Geneveys-Villiers	8·2 — (5·1 —).
Total. . .	63·8 kilometres (39·6 miles).

On January 1, 1905, about 100 kilometres (62 miles) of electric railways were under construction and concessions for about 620 kilometres (385 miles) (purely electric traction) had been granted.

These statistics show that the development of electric traction is relatively much greater in Switzerland than in say Germany. Up to the present, electric traction has only been used in two cases on main lines; but we know that the question of its adoption is the subject of serious study by the parties concerned. As regards the

KIND OF CURRENT

used, we find, besides continuous current which is most frequently used, also numerous applications of the three-phase current; whereas in Germany, there is no regular railway using three-phase current, the Marienfelde-Zossen line having only been an experimental one. In Switzerland, on the other hand, this system is used on one main line, three secondary lines (including mountain lines with rack), two tramways and two cable railways (1). It is a remarkable fact that monophase current has not yet been used, except on the Oerlikon experimental section in 1905; whereas in Germany, there are already 28 kilometres (17·4 miles) (Murnau and Spindlersfeld) open operated on this system, and 26 kilometres (16·2 miles) more (Altona) under construction. On most of the lines, the current is generated at own power stations; about 35 per cent of the lines obtain their power from other sources. In forty cases, the current is generated at working pressure; in fifteen it is generated or supplied as high-pressure three-phase current, which is then converted into continuous current; in one case, high-pressure continuous current (1,400 volts) generated on the Thury system is then transformed into current at working pressure; in eight cases, high-pressure three-phase current is transformed at transformer substations into three-phase current at working pressure. The working pressure varies, in the case of continuous current, between 450 and 800 volts (most frequently 550 volts), and in that of three-phase current, between 400 and 750 volts.

The current is distributed in all cases (except the third rail of the standard gauge line Freiburg-Murten-Ins and the Oerlikon experimental section) by means of the usual conducting wire supported by brackets or hung from stretched wires. Underground mains and accumulators are not used. Trolleys are more frequently used than bows, for collecting current; in

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(1) All these data apply to the year 1903.

		a	b	c	d				e	f	g	h	i	k	l
Index number (*).	LINE.	Gauge of track, in metres.	Length open, in kilometres (miles).	Steepest gradient, per mil.	Locomotives and rolling stock: L = locomotives, M = motor cars, P = passenger trailers, G = goods trailers.				Train-kilometres (train-miles) (goods trains included).	Number of passengers carried.	Total construction cost, in francs.	Construction cost per kilometre (per mile) of line, in francs.	Total receipts, in francs.	Coefficient of working, per cent.	Dividends on shares, per cent.
	A. — Main lines and secondary lines.				*L*	*M*	*P*	*G*							
1	Burgdorf-Thun	1·435 (4′ 8 1/2″)	40·214 (24·988)	25	3(1)	6	16	67	277,437 (172,394)	508,850	5,434,556 (£217,382. 5s.)	158,981 (£10,234. 1s.)	463,843 (£18,553.14s.)	83·41	...
2	Freiburg-Murten-Ins	1·435 (4′ 8 1/2″)	32·301 (20·071)	30	...	3	7	25	164,883 (102,455)	186,245	2,692,953 (£107,718. 2s.)	104,780 (£6,744.19s.)	203,280 (£8,131. 4s.)	93·59	...
3	Orbe-Chavornay	1·435 (4′ 8 1/2″)	3·899 (2·423)	25	...	4	3	3	41,512 (25,795)	76,361	488,421 (£19,536.17s.)	121,378 (£7,813. 8s.)	58,129 (£2,325.. 3s.)	66·01	3·50
4	Aarau-Schöftland	1·000 (3′ 3 3/8″)	11·049 (6·866)	46	...	4(2)	5	8	103,520 (64,326)	273,114	808,739 (£32,349.11s.)	72,190 (£4,647. 1s.)	84,866 (£3,394.13s.)	68·69	2·00
5	Aigle-Leysin	1·000 (3′ 3 3/8″)	6·785 (4·216)	100 230	4(1)	4	7	7	47,076 (29,252)	51,879	1,837,345 (£73,493.16s.)	269,276 (£17,334)	129,248 (£5,169.18s.)	61·61	...
6	Bex-Gryon-Villars	1·000 (3′ 3 3/8″)	12·444 (7·732)	57 200	3	8	9	8	94,140 (58,497)	144,672	1,579,270 (£63,170.16s.)	126,619 (£8,150.16s.)	122,348 (£4,893.18s.)	63·63	1·67
7	Bremgarten-Dietikon	1·000 (3′ 3 3/8″)	10·836 (6·733)	60	...	3	6	4	68,505 (42,568)	94,579	745,243 (£29,809.14s.)	68,085 (£4,382.16s.)	68,684 (£2,747. 7s.)	83·52	...
8	Châtel-Bulle-Montbovon	1·000 (3′ 3 3/8″)	32·296 (20·068)	32	...	6	11	27	76,733 (47,681)	92,845	3,875,280 (£155,011. 4s.)	117,159 (£7,541.16s.)	88,341 (£3,533.13s.)	74·26	...
9	Châtel-Palézieux	1·000 (3′ 3 3/8″)	6·807 (4·230)	32	...	2	3	9	49,620 (30,833)	70,802	769,440 (£30,777.12s.)	113,994 (£7,338. 1s.)	51,504 (£2,060. 3s.)	124·67	...
10	Geneva-Veyrier	1·000 (3′ 3 3/8″)	5·548 (3·447)	50	2(4)	6	18	4	195,500 (121,480)	558,749	754,518 (£30,180.14s.)	118,249 (£7,612)	131,749 (£5,269 19s.)	64·16	4·50
11	Grütschalp-Mürren	1·000 (3′ 3 3/8″)	4·279 (2·659)	50	...	3	2	2	12,200 (7,581)	46,221	648,278 (£25,931. 2s.)	150,043 (£9,658.13s.)	52,828 (£2,113. 2s.)	70·96	5·00
12	Lausanne-Moudon and Savigny	1·000 (3′ 3 3/8″)	26·947 (16·744)	70	...	7	7	8	178,853 (111,136)	333,954	2,714,873 (£108,594.18s.)	99,248 (£6,388.16s.)	136,679 (£5,467. 3s.)	90·16	...
13	Montreux-Berner Oberland	1·000 (3′ 3 3/8″)	22·133 (13·753)	67	...	6	9	11	90,600 (56,297)	109,932	6,199,978 (£247,999. 2s.)	280,855 (£18,079. 7s.)	184,066 (£7,362 13s.)	53·94	...
14	St. Gallen-Speicher-Trogen	1·000 (3′ 3 3/8″)	9·980 (6·201)	75	...	6(3)	6	7	42,199 (26,222)	130,260	1,419,966 (£56,798.13s.)	150,210 (£9,669. 8s.)	83,418 (£3,336.14s.)	76·45	...
15	Sissach-Gelterkinden	1·000 (3′ 3 3/8″)	3·148 (1·956)	15	2(4)	1	4	2	25,468 (15,825)	142,692	397,641 (£15,905.13s.)	122,313 (£7,873.11s.)	32,274 (£1,290.19s.)	97·52	...
16	Stanstad-Engelberg	1·000 (3′ 3 3/8″)	22·518 (13·992)	50 250	3	8	11	15	174,006 (108,124)	175,354	2,629,054 (£105,162. 3s.)	116,575 (£7,504. 5s.)	310,125 (£12,405)	49·59	4·13
17	Vevey-Chamby	1·000 (3′ 3 3/8″)	8·532 (5·302)	50	...	6	9	6	79,552 (49,432)	132,701	1,352,604 (£54,104. 3s.)	157,679 (£10,150. 4s.)	66,143 (£2,645.14s.)	66·86	...
18	Wetzikon-Meilen	1·000 (3′ 3 3/8″)	22·476 (13·966)	61	...	7	10	8	43,694 (27,151)	95,451	1,605,758 (£64,230. 6s.)	71,363 (£4,593.16s.)	30,714 (£1,228.11s.)	65·63	...
19	Gornergrat	1·000 (3′ 3 3/8″)	9·022 (5·606)	200	5(1)	...	7	2	11,877 (7,380)	34,278	3,345,598 (£133,823.18s.)	307,761 (£19,811. 8s.)	276,310 (£11,052. 8s.)	33·98	4·00
20	Jungfrau	1·000 (3′ 3 3/8″)	4·339 (2·696)	250	5	...	10	4	8,503 (5,284)	57,167	4,616,056 (£184,642. 5s.)	1,018,759 (£65,580. 3s.)	266,041 (£10,641.13s.)	39·75	...
	B. — Tramways.														
21	Allaman-Aubonne-Gimel	1·000 (3′ 3 3/8″)	9·913 (6·160)	60	...	6(2)	1	7	85,657 (53,226)	101,539	641,586 (£25,663. 9s.)	64,114 (£4,127. 3s.)	41,701 (£1,788. 1s.)	94·00	1·11
22	Altstätten-Berneck	1·000 (3′ 3 3/8″)	11·239 (6·984)	52	...	7	...	...	171,002 (108,122	522,233	563,003 (£22,520. 2s.)	49,613 (£3,193.14s.)	88,461 (£3,538. 9s.)	70·51	...
23	Bale tramways	1·000 (3′ 3 3/8″)	23·323 (14·493)	72	...	78	20	...	2,772,913 (1,723,039)	12,195,169	6,546,538 (£261,861.10s.)	277,654 (£17,873. 6s.)	1,362,070 (£54,482.16s.)	69·44	4·00
24	Birseck tramway	1·000 (3′ 3 3/8″)	6·276 (3·900)	50	...	4	...	...	213,164 (132,456)	597,750	590,744 (£23,629.15s.)	92,031 (£5,924. 6s.)	121,980 (£4,879. 4s.)	67·60	4·50
25	Berne tramways	1·000 (3′ 3 3/8″)	10·815 (6·720)	55	2(4)	31	12	...	1,287,415 (799,977)	6,647,416	2,516,558 (£100,662. 6s.)	224,934 (£14,479.11s.)	672,354 (£26,894. 3s.)	74·18	3·50
26	Biel tramways	1·000 (3′ 3 3/8″)	5·016 (3·117)	14	...	12	5	9	406,809 (252,784)	1,011,268	761,205 (£30,448. 4s.)	151,755 (£9,768.17s.)	131,068 (£5,242.14s.)	92·30	0·13
27	Chaux-de-Fonds tramway	1·000 (3′ 3 3/8″)	3·325 (2·066)	79	...	7	...	...	216,076 (134,266)	681,387	393,005 (£15,720. 4s.)	118,198 (£7,608.14s.)	67,471 (£2,698.17s.)	98·10	...
		1·000	0·637	98	...	1	...	...	6.692	26,776	85,633	134,433	8,533	100·00	...

30	Lausanne tramways	1·000 (3' 3 3/8")	23·200 (14·416)	127	...	50	2	3	979,696 (608,766)	4,034,529	2,819,915 (£112,796.12s.)	125,823 (£8,099.10s.)	513,431 (£20,537. 5s.)	88·94	1·44
31	Limmattal tramway	1·000 (3' 3 3/8")	12·008 (7·462)	52	...	10	3	1	268,028 (166,548)	585,780	1,265,613 (£50,624.10s.)	105,398 (£6,784.14s.)	72,641 (£2,905.13s.)	104·85	...
32	Lugano tramway	1·000 (3' 3 3/8")	4·538 (2·820)	60	...	5	...	...	153,385 (95,311)	653,360	215,738 (£8,629.10s.)	47,033 (£3,027.12s.)	58,749 (£2,349.19s.)	82·36	4·00
33	Lucerne tramways	1·000 (3' 3 3/8")	10·617 (6·597)	47	3 (4)	26	...	...	990,433 (5) (615,138)	2,804,536	2,148,138 (£85,925.10s.)	153,943 (£9,909.14s.)	368,341 (£14,733.13s.)	87·54	1·66
34	Neuchatel tramways	1·000 (3' 3 3/8")	26·346 (16·371)	86	...	30	18	12	931,541 (578,843)	3,071,290	2,918,348 (£116,733.18s.)	108,719 (£6,998.10s.)	441,769 (£17,670.15s.)	70·34	2·57
35	Riffelalp (Zermatt) tramway	0·800 (2' 7 1/2")	0·468 (0·291)	50	...	2 (2)	...	...	1,550 963	1,453	53,895 (£2,155.16s.)	112,281 (£7,227.17s.)	2,348 (£93.18s.)	92·33	0·33
36	Rolle-Gimmel	1·000 (3' 3 3/8")	10·528 (6·542)	84	...	4 (2)	...	...	67,072 41,677	68,025	612,936 (£24,517. 9s.)	57,9 6 (£3,727.12s.)	35,670 (£1,426.16s.)	95·73	...
37	St. Gallen tramway	1·000 (3' 3 3/8")	9·292 (5·774)	64	...	34	6	...	944,746 (587,049)	3,460,000	1,558,879 (£62,355. 3s.)	167,766 (£10,799.11s.)	443,733 (£17,749. 6s.)	76·71	3·63
38	St. Moritz tramway	1·000 (3' 3 3/8")	1·635 (1·016)	50	...	4	...	...	24,974 (15,518)	126,632	351,013 (£14,040.10s.)	207,823 (£13,378. 1s.)	21,593 (£863.14s.)	108·48	...
39	Schaffhausen tramway	1·000 (3' 3 3/8")	3·992 (2·481)	81	...	9	1	...	257,045 (159,723)	596,417	576,020 (£23,040.16s.)	139,303 (£8,967. 5s.)	82,663 (£3,306.10s.)	88·26	1·50
40	Schwyz-Seewen	1·000 (3' 3 3/8")	1·725 (1·072)	60	...	3	...	...	31,372 (19,494)	159,667	201,968 (£8,078.14s.)	107,946 (£6,948.16s.)	25,861 (£1,034. 9s.)	70·16	...
41	Geneva tramways	1·000 (3' 3 3/8")	125·687 (78·100)	120	4 (4)	95	50	48	3,767,312 (6) (2,340,941)	12,466,767	13,460,098 (£538,403.18s.)	107,949 (£6,918.19s.)	1,953,486 (£78,139. 9s.)	91·05	...
42	Val-de-Ruz	1·000 (3' 3 3/8")	8·139 (5·057)	72	...	5	...	1	109,481 (68,030)	293,194	536,508 (£21,460. 6s.)	65,269 (£4,201.10s.)	55,128 (£2,205. 2s.)	110·90	...
43	Vevey-Chillon (rack section included)	1·000 (3' 3 3/8")	10·882 (6·762)	35 150	...	24	...	...	630,573 (391,827)	1,824,579	888,963 (£35,558.10s.)	81,691 (£5,258.14s.)	289,958 (£11,598. 6s.)	68·13	...
44	Chillon-Villeneuve	1·000 (3' 3 3/8")	2·575 (1·600)	40	...	3	...	...	2,458 (1,527)	3,035	95,100 (£3,804)	36,933 (£2,377. 9s.)	515 (£20.12s.)	259·22	...
45	Winterthur-Töss	1·000 (3' 3 3/8")	1·798 (1·117)	...	...	4	1	...	119,636 (74,340)	558,740	215,295 (£8,611.16s.)	105,330 (£4,213. 4s.)	51,808 (£2,072. 6s.)	85·83	1·93
46	Zürichberg power station line	1·000 (3' 3 3/8")	4·221 (2·623)	70	...	14	...	...	411,718 (255,834)	1,055,397	837,216 (£33,488.13s.)	243,448 (£15,671. 7s.)	158,198 (£6,327.18s.)	97·29	...
47	Zurich tramways	1·000 (3' 3 3/8")	24·327 (15·116)	61	...	109	20	...	3,123,641 (1,940,976	13,290,823	7,535,551 (£301,422. 1s.)	299,339 (£19,269. 4s.)	1,617,313 (£64,692.10s.)	61·30	3·97
48	Zurich-Höngg	1·000 (3' 3 3/8")	3·012 (1·872)	60	...	6	...	...	97,145 (60,364)	246,607	372,908 (£14,916. 6s.)	121,310 (£7,809. 1s.)	34,201 (£1,368. 1s.)	101·70	...
49	Zurich-Oerlikon-Seebach	1·000 (3' 3 3/8")	5·500 (3·418)	64	...	21	...	...	602,804 (374,572)	1,679,051	1,452,070 (£58,082.16s.)	262,296 (£16,884.14s.)	248,546 (£9,941.17s.)	70·38	5·00
	C. — Cable railways.														
50	Biel-Leubringen	1·000 (3' 3 3/8")	0·892 (0·554)	360	...	...	2	...	22,926 (14,246)	187,698	305,178 (£12,207. 2s.)	339,841 (£21,876. 9s.)	46,103 (£1,844. 2s.)	68·43	3·00
51	Bürgenstock	1·000 (3' 3 3/8")	0·827 (0·514)	375	...	...	2	...	7,501 (4,661)	54,355	270,000 (£10,800)	324,910 (£20,915. 6s.)	52,665 (£2,106.12s.)	64·86	5·00
52	Davos-Schatzalp	1·000 (3' 3 3/8")	0·640 (0·398)	474	...	...	2	...	15,081 (9,371)	61,122	374,349 (£14,973 19s.)	575,923 (£37,073.13s.)	45,028 (£1,801. 2s.)	77·28	...
53	Dolder line (Zurich)	1·000 (3' 3 3/8")	0·799 (0·496)	177	...	...	2	...	43,627 (27,109)	199,500	286,433 (£11,457. 6s.)	353,620 (£22,763. 9s.)	41,398 (£1,655.18s.)	58·86	...
54	Gurten line (Berne)	1·000 (3' 3 3/8")	1·021 (0·634)	330	...	...	2	...	16,252 (10,099)	76,410	363,913 (£14,556.10s.)	352,288 (£22,677.13s.)	38,626 (£1,545. 1s.)	64·11	...
55	Kriens-Sonnenberg	1·000 (3' 3 3/8")	0·803 (0·499)	425	...	...	2	...	9,953 (6,185	52,462	388,475 (£15,539)	478,421 (£30,797. 4s.)	39,788 (£1,591.10s.)	47·07	4·50
56	Lausanne-Signal	1·000 (3' 3 3/8")	0·455 (0·283)	290	...	...	2	...	10,732 (6,669)	121,079	353,696 (£14,147)	760,636 (£48,964. 3s.)	24,860 (£994. 8s.)	55·57	...
57	Lauterbrunnen-Grütschalp	1·000 (3' 3 3/8")	1·207 (0·750)	600	...	...	2	...	5,830 (3,623)	48,695	896,361 (£35,854. 9s.)	736,533 (£47,412.10s.)	118,659 (£4,745.11s.)	28·61	...
58	Reichenbach (Meiringen)	1·000 (3' 3 3/8")	0·661 (0·411)	617	...	...	2	...	3,535 (2,197)	22,024	349,000 (£13,960)	523,838 (£33,720.16s.)	15,433 (£617. 6s.)	73·30	...
59	Salvatore (Lugano)	1·000 (3' 3 3/8")	1·507 (0·936)	600	...	...	2	...	7,797 (4,845)	48,570	630,531 (£25,221. 5s)	413,734 (£26,633. 2s.)	78,450 (£3,138)	40·02	8·00
60	St. Imier-Sonnenberg	1·000 (3' 3 3/8")	0·642 (0·399)	600	...	...	2	...	3,697 (2,297)	62,908	248,213 (£9,928.10s)	382,453 (£24,619. 9s.)	19,009 (£760. 7s.)	41·19	...
61	Stanserhorn	1·000 (3' 3 3/8")	3·600 (2·237)	630	...	...	6	...	16,849 (10,470)	19,328	1,483,745 (£59,349.16s.)	409,196 (£26,341)	57,748 (£2,309.18s)	80·78	...
62	Vevey-Pèlerin	1·000 (3' 3 3/8")	1·514 (0·941)	580	...	...	2	...	18,716 (11,630)	164,671	737,521 (£29,500.17s.)	483,303 (£31,111. 9s.)	72,818 (£2,912.14s.)	50·90	...
63	Zurichbergline	1·000 (3' 3 3/8")	0·163 (0·101)	260	...	...	2	...	16,122 (10,018)	400,918	272,906 (£10,916. 5s.)	1,595,941 (£102,734.18s.)	39,614 (£1,584.11s.)	66·25	4·50
64	Zurich-Rigiviertel	1·000 (3' 3 3/8")	0·284 (0·176)	330	...	...	2	...	14,718 (9,146)	126,970	253,800 (£10,152)	824,178 (£53,054. 9s.)	14,913 (£596.10s.)	88·43	...

Remarks : (*) These numbers are the same as those marked on the map (fig. 3); the latter is taken from Grieben's guide to Switzerland. — (1) Including one steam locomotive. — (2) Including one goods motor car. — (3) Including two goods motor cars. — (4) Steam locomotives only. — (5) Including 3,863 kilometres (2,400 miles) by steam locomotives. — (6) Including 33,333 kilometres (20,713 miles) by steam locomotives and 31,048 kilometres (19,293 miles) by horse traction.

Table II.

Cost of conductors on main and secondary lines.

Index number.	LINE (MAIN AND SECONDARY RAILWAYS).	COST OF CONDUCTORS.		
		Total, in francs.	Per kilometre (per mile) of line, in francs.	Per cent of total construction cost.
1	Burgdorf-Thun	604,453 (£24,178. 2s.)	18,083 (£1,170. 9s.)	12·1
2	Freiburg-Murten-Ins	360,121 (£14,404.17s.)	14,323 (£ 922. 0s.)	13·4
3	Orbe-Chavornay	25,388 (£1,015.10s.)	6,269 (£ 250.15s.)	5·2
4	Aarau-Schöftland.	114,871 (£4,594.17s.)	10,235 (£ 658.17s.)	14·2
5	Aigle-Leysin	92,778 (£3,711. 2s.)	13,588 (£ 874.13s.)	5·1
6	Bex-Gryon-Villars	108,093 (£4,323.14s.)	8,671 (£ 558. 4s.)	6·8
7	Bremgarten-Dietikon.	94,213 (£3,768.10s.)	8,601 (£ 553.14s.)	12·6
8	Châtel-Bulle-Montbodon.	453,414 (£18,136.11s.)	13,664 (£ 879.11s.)	11·7
9	Châtel-Palézieux	84,476 (£3,379. 1s.)	12,535 (£ 806.18s.)	10·9
10	Geneva-Veyrier	140,956 (£5,638. 5s.)	25,139 (£1,618. 5s.)	18·6
11	Grütschalp-Mürren	27,500 (£1,100. 0s.)	6,363 (£ 409.11s)	4·2
12	Lausanne-Moudon and Savigny.	333,638 (£13,345.10s.)	12,176 (£ 783.16s.)	12·3
13	Montreux-Berner Oberland	306,938 (£12,277.10s.)	13,910 (£ 895. 8s.)	4·9
14	St. Gallen-Speicher-Trogen	166,998 (£6,679.18s.)	17,843 (£1,148.11s.)	11·8
15	Sissach-Gelterkinden	35,000 (£1,400. 0s.)	10,726 (£ 690.10s.)	8·8
16	Stanstad-Engelberg	230,659 (£9,226. 7s.)	10,231 (£ 658.12s.)	8·8
17	Vevey-Chamby	91,480 (£3,659. 4s.)	10,686 (£ 687.18s.)	6·8
18	Wetzikon-Meilen	176,423 (£7,056.18s.)	7,841 (£ 504.15s.)	10·9
19	Gornergrat	110,118 (£4,404.14s.)	12,105 (£ 779. 5s.)	3·3
20	Jungfrau	200,045 (£8,001.16s.)	44,034 (£2,834.11s.)	4·3
	Mean per kilometre (per mile) of line. .	...	13,856 (£ 891.19s.)	9·3

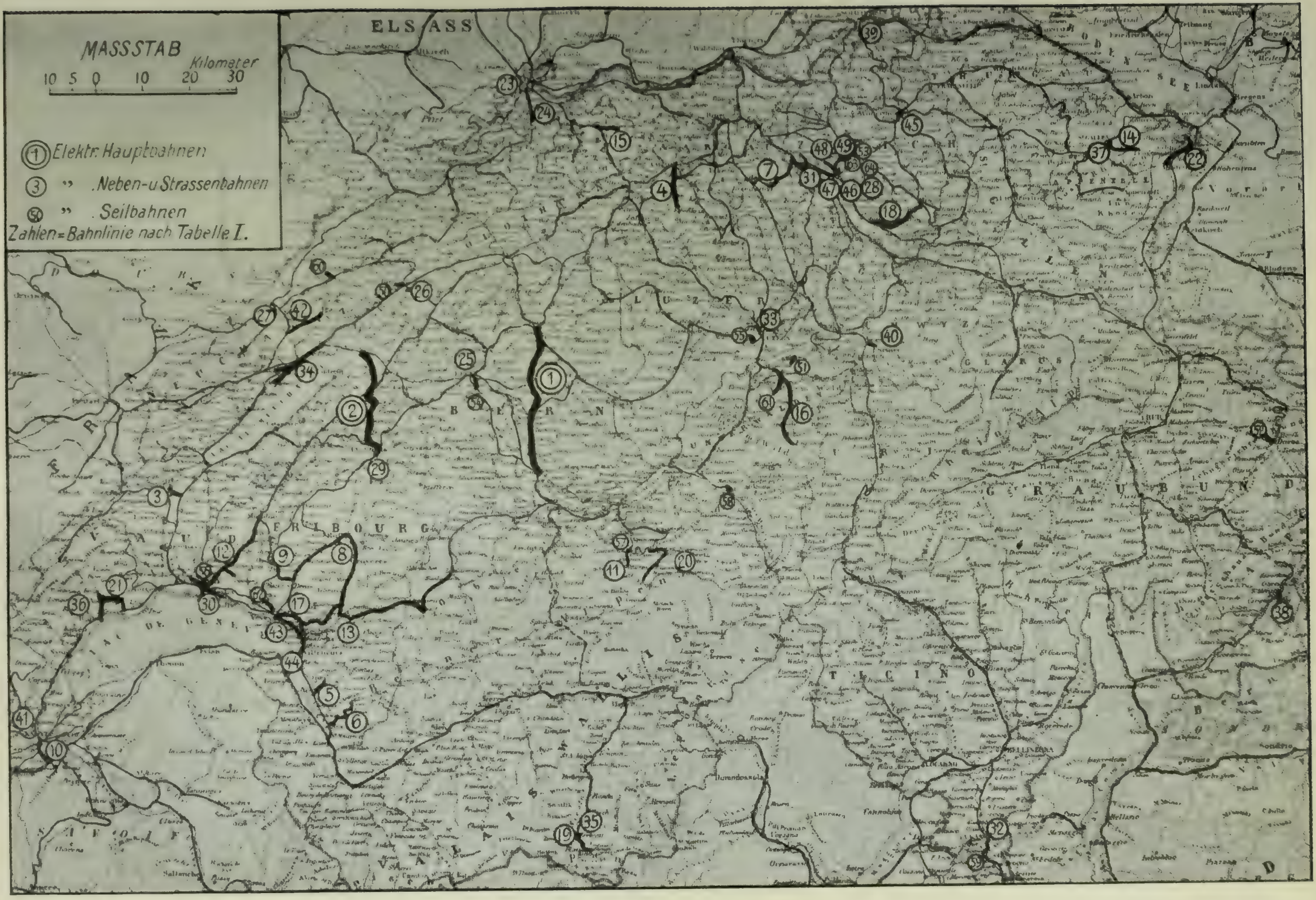

Fig. 3.

Explanation of German terms : Massstab = Scale. — Elektr. Hauptbahnen = Electric main lignes. — Elektr. Neben u. Strassenbahnen = Electric secondary lines and tramways. — Elektr. Seilbahnen = Electric cable railways. — Zahlen-Bahnlinie nach Tabelle I = Numbers of the lines as in table I.

order to avoid the use of overhead switches two conducting wires are frequently used (with the trolley).

COST OF CONDUCTORS.

Table II shows the cost of construction of the conductors of the main and secondary railways. It varies between 6,000 and 25,000 francs per kilometre (between £400 and £1,600 per mile) (the Jungfrau line, with 44,034 francs [£2,834.11*s*. per mile], may be considered an abnormal case), and averages about 14,000 francs per kilometre (£885 per mile). The cost of the conductors amounts to from 3 to 18, average 9·3 per cent, of the total cost of construction.

GAUGE OF THE TRACK.

With the exception of the two main lines, the secondary standard-gauge line Orbe-Chavorney and the small Riffelalp tramway (gauge 80 centimetres [2 ft. 7 $^1/_2$ in.], one car only in use), all the electric lines in Switzerland have a gauge of 1 metre (3 ft. 3 $^3/_8$ in.). In Germany, the standard gauge is much used, for instance on the tramways; but of late there is also a tendency in favour of the metre (3 ft. 3 $^3/_8$ in.) gauge. The cost of construction and of maintenance is consequently very reasonable.

ROADBED AND TRACK.

There is nothing special about the roadbed; most of the secondary railways are laid, in the country, on the public highways.

The track has Vignoles rails and wooden or iron sleepers, or channel rails and tie rods; on mountain lines and cable railways rails with conical heads, for the grip-brake, are used.

Most of them are single-track lines. The total length of the main and secondary railways of Switzerland, open to traffic, is 4,078 kilometres (2,534 miles); of this there are only about 543 kilometres (337 miles) of double track.

PROFILE.

The steepest gradient on main and secondary lines is, in one case (Aigle-Leysin), 100 per mil; in other cases, it is 75 per mil on adhesion sections and 250 per mil on rack sections. Nearly all the tramways have gradients steeper than 60 per mil; up to 98 per mil, no special braking appliances are provided. At Freiburg, Lausanne and Geneva, simple adhesion traction is even used on gradients of 102, 120 and 127 per mil respectively; but then grip-brakes are used. The steepest gradient on a cable railway is the very considerable one of 630 per mil, and that without rack for braking purposes; only grip-brakes seizing the conical head of the rail are used.

CURVES.

The sharpest curves have a radius of 180 metres (9 chains) on standard-gauge line, of 18 metres ($^9/_{10}$ chain) on secondary lines, of 10 metres ($^1/_2$ chain) on tramways (at loops) and of 100 metres (5 chains) on cable railways (at passing places).

SPEED.

The speed is 35 to 36 kilometres (21·7 to 22·4 miles) per hour on main lines, 25 to 40 kilometres (15·5 to 24·9 miles) per hour on secondary lines, 10 to 40 kilometres (6·2 to 15·5 miles) per hour on tramways, 5 to 8 kilometres (3 to 5 miles) per hour on rack railways and 4 to 10 kilometres (2·5 to 6·2 miles) per hour on cable railways.

ROLLING STOCK.

In 1903, the total rolling stock of the Swiss electric railways included 1,376 vehicles (as against 19,838 for the whole railway system), namely : 20 electric locomotives (16 steam locomotives), 693 passenger motor cars, 6 goods motor cars, 335 passenger trailers and 306 goods trailers. The motor cars generally have two axles; all the axles are driving axles; the same applies to the cars with four axles. However, there are also cars with two axles and one motor only, and cars with four axles and two motors only (sometimes the motors are on the leading bogie only); in some rare cases, the cars have radial axle-boxes. Two mountain lines and one secondary line have no motor cars, but only electric locomotives. The cable railways are worked by stationary motors situated at the upper end of the line. The brakes used are : hand brake, compressed air brake, Schiemann brake acting on rail, short-circuiting brakes and automatic brakes (mountain lines and cable railways).

The cost of the rolling stock on the twenty main and secondary lines, represents from 6·3 to 25·7, average 14·3 per cent, of the total cost of construction (*see* table III).

COST OF CONSTRUCTION.

As regards the two main lines with electric traction, the total outlay per kilometre was materially less on the continuous current line Freiburg-Murten-Ins (third rail) than on the three-phase current line Burgdorf-Thun (104,780 as against 158,980 francs per kilometre [£6,744.19*s*. as against £10,234 per mile]). This is due partly to the greater cost of the conductors, and chiefly to that of the rolling stock (per kilometre of line, Freiburg, 8,155 francs [£524.19*s*. per mile] as against Burgdorf, 21,160 francs [£1,362.6*s*, per mile]); the other items are also generally higher (*see* table III).

The total outlay, per kilometre, on the sixteen secondary electric lines (Nos. 3 to 18) varied between 68,085 and 280,855 francs (between £4,382.16*s*. and £18,079.7*s*. per mile), the average being 133,921 francs (£8,620.17*s*. per mile); on the two mountain lines using three-phase current (rack only) it was 307,761 francs (£19,811.8*s*. per mile) on the Gornergrat railway, and it reached the very high figure of 1,018,759 francs (£65,580.3*s*. per mile) on the Jungfrau railway.

On the electric tramways, the corresponding figures, per kilometre of line, vary between 36.932 and 299,339 francs (between £2,377.9*s*. and £19,269.4*s*. per mile), average 134,854 francs (£8,680.18*s*. per mile); on cable railways between 324,910 and 1,595,937 francs (between £20,915.6*s*. and £102,734.13*s*. per mile), average 573,321 francs per kilometre (£36,906.4*s*. per mile).

The total capital invested in Swiss electric railways is 101,750,000 francs (£4,070,000), being 7·2 per cent of the total invested in all the Swiss railways (1,419 millions of francs [£56,760,000]). Capital outlay on all the German railways : 17,000 million francs (£680 millions); on all the railways of the whole world : 215,000 million francs (£8,600 millions), in round figures. Later on we give other comparisons.

RESULTS OF WORKING.

In 1903, the Swiss railways carried 142·9 million passengers and 12·5 million metric tons (12·3 million English tons) of goods (luggage and animals included). The electric railways

Table III. — Cost of rolling stock and of track of the electric main and secondary lines.

Index number.	LINE (MAIN AND SECONDARY RAILWAYS).	COST OF ROLLING STOCK.			GENERAL EXPENSES (organization, administration, technical management, interest on capital).		COST PER KILOMETRE (PER MILE) OF TRACK, IN FRANCS.					
		Total, in francs.	Per axle, in francs (average of all vehicles).	Per cent of total construction cost.	Per kilometre (per mile) of line, in francs.	Per cent of total construction cost.	Roadbed.	Superstructure.	Land.	Constructional work and mechanical appliances at stations.	Telegraphs, signals, fencing, notice boards and posts.	Furniture, tools and appliances.
1	Burgdorf-Thun	852,836 (£34,113.9s.)	4,043 (£161.14s.)	15·7	6,755 (£434.17s.)	4·13	39,711 (£2,556.6s.)	29,104 (£1,873.10s.)	24,614 (£1,584.10s.)	13,536 (£871.7s.)	3,258 (£209.14s.)	2,660 (£171.5s.)
2	Freiburg-Murten-Ins	263,435 (£10,537.8s.)	3,213 (£128.10s.)	9·8	3,986 (£256.12s.)	3·72	27,684 (£1,782.1s.)	22,933 (£1,476.4s.)	11,305 (£727.15s.)	12,421 (£799.12s.)	2,386 (£153.12s.)	1,588 (£102.4s.)
3	Orbe-Chavornay	92,454 (£3,698.3s.)	4,623 (£184.18s.)	18·9	4,295 (£276.10s.)	3·57	42,963 (£2,765.12s.)	27,533 (£1.772.7s.)	10,366 (£667.6s.)	4,819 (£310.4s.)	516 (£33.5s.)	920 (£59.4s.)
4	Aarau-Schöftland	130,916 (£5.236.13s.)	2,425 (£97)	16·2	1,519 (£97.15s.)	2·11	7,281 (£468.14s.)	22,708 (£1,461.15s.)	6,224 (£400.13s.)	10,413 (£670.6s.)	1,074 (£69.2s.)	944 (£60.15s.)
5	Aigle-Leysin	308,104 (£12,324.3s.)	5,405 (£216.4s.)	16·7	16,561 (£1,066.2s.)	6·15	85,953 (£5,533)	47,665 (£3,068.6s.)	19,328 (£1,244.3s.)	37,368 (£2,405.9s.)	401 (£25.17s.)	3,104 (£199.16s.)
6	Bex-Gryon-Villars	310,238 (£12,409.10s.)	3,975 (£159)	19·6	8,088 (£520.12s.)	6·38	39,303 (£2,530)	36,376 (£2,341.13s.)	4,353 (£280.4s.)	3,680 (£236.18s.)	140 (£9)	1,191 (£76.14s.)
7	Bremgarten-Dietikon	102,908 (£4,116.6s.)	3,958 (£158.6s.)	13·8	1,843 (£118.12s.)	2·71	9,745 (£627.6s.)	18,993 (£1,222.12s.)	4,255 (£273.18s.)	12,748 (£820.12s.)	219 (£14.2s.)	2,244 (£144.9s.)
8	Châtel-Bulle-Montbovon	452,323 (£18,092.18s.)	4,039 (£161.11s.)	11·6	8,299 (£534.4s.)	7·11	32,019 (£2,061.3s.)	26,489 (£1,705.3s.)	713 (£45.17s.)	19,931 (£1,283.1s.)	1,003 (£64.11s.)	1,039 (£66.17s.)
9	Châtel-Palézieux	136,995 (£5.479.16s.)	3,805 (£152.4s.)	17·8	5,023 (£323.6s.)	4·40	20,639 (£1,328.11s.)	20,211 (£1,301.1s.)	8,779 (£565.2s.)	24,019 (£1,546.3s.)	979 (£63)	1,664 (£107.2s.)
10	Geneva-Veyrier	194,255 (£7,770.4s.)	3,134 (£125.7s.)	25·7	4,979 (£320.10s.)	3·70	30,148 (£1,940.13s.)	20,558 (£1,323.7s.)	5,794 (£372.19s.)	9,558 (£615.5s.)	1,608 (£103.10s.)	2,140 (£137.15s.)
11	Grütschalp-Mürren	67,000 (£2,680)	3,723 (£148.18s.)	10·3	8,080 (£520.3s.)	5·39	69,846 (£4,496.4s.)	17,423 (£1,121.11s.)	9,524 (£613.1s.)	20,024 (£1,289)	1,619 (£104.4s.)	1,583 (£101.17s.)
12	Lausanne-Moudon and Savigny	309,286 (£12,371.9s.)	5,523 (£220.18s.)	11·4	6,096 (£392.9s.)	6·15	19,476 (£1,253.15s.)	31,781 (£2,045.17s.)	2,819 (£181.9s.)	13,294 (£855.15s.)	1,133 (£72.18s.)	1,019 (£65.12s.)
13	Montreux-Berner Oberland	432,640 (£17,305.12s.)	4,415 (£176.12s.)	7·0	16,403 (£1,055.17s.)	5·84	136,896 (£8,812.7s.)	38,568 (£2,482.14s.)	24,941 (£1,605.11s.)	27,448 (£1,766.17s.)	1,095 (£70.10s.)	2,108 (£135.13s.)
14	St.-Gallen-Speicher-Trogen	218,828 (£8,753.2s.)	4,053 (£162.2s.)	15·4	6,301 (£405.16s.)	4·16	21,419 (£1.378.16s.)	24,539 (£1,579.12s.)	23,305 (£1,500.4s.)	28,679 (£1,846.3s.)	2,585 (£166.8s.)	3,655 (£370.19s.)
15	Sissach-Gelterkinden	74,246 (£2,969.17s.)	4,125 (£165)	18·7	3,354 (£215.18s.)	2·75	29,940 (£1,927.6s.)	18,929 (£1.218.10s.)	16,308 (£1,049.15s.)	8,428 (£542.10s.)	10,156 (£653.16s.)	1,238 (£79.13s.)
16	Stanstad-Engelberg	391,575 (£15,663)	3,626 (£145.1s.)	14·9	2,915 (£187.13s.)	2·50	22,469 (£1.446.7s.)	24,678 (£1,588.12s.)	15,776 (£1,015.11s.)	20,283 (£1,305.13s.)	1,328 (£85.9s.)	1,571 (£101.3s.)
17	Vevey-Chamby	127,793 (£5,111.14s.)	2,366 (£94.13s.)	9·5	5,798 (£373.4s.)	3·67	45,706 (£2,942.5s.)	24,974 (£1,607.13s.)	31,979 (£2,058.11s.)	22,531 (£1,450.8s.)	343 (£22.1s.)	1,053 (£67.15s.)
18	Wetzikon-Meilen	293,958 (£11,758.6s.)	4,741 (£189.13s.)	18·3	3,328 (£214.4s.)	4·66	13,734 (£884.2s.)	19,191 (£1,235.8s.)	6,961 (£448.2s.)	5,811 (£374.2s.)	378 (£24.6s.)	1,054 (£67.17s.)
19	Gornergrat	209,404 (£8,376.3s.)	5,660 (£226.8s.)	6·3	26,211 (£1,687.6s.)	7·13	158,018 (£10,172)	57,624 (£3,709.8s.)	27,743 (£1,785.17s.)	58,343 (£3,755.13s.)	1,191 (£76.14s.)	3,519 (£226.10s.)
20	Jungfrau	374,364 (£14,974.11s.)	8,509 (£340.7s.)	8·1	153,345 (£9,871.4s.)	15·09	379,833 (£24,450.16s.)	65,871 (£4,240.6s.)	22,013 (£1,417)	262,488 (£16,897)	1,998 (£128.12s.)	4,093 (£263.9s.)

contributed to these totals 74·5 million passengers and 343,000 metric tons (337,500 English tons) of goods, as follows :

1903.	Passengers.	Metric tons (English tons) of goods.
2 electric main lines	695,095	128,564 (126,533)
18 — secondary lines	2,621,011	113,856 (112,058)
29 — tramways	69,554,205	93,581 (92,103)
15 — cable railways	1,645,860	6,930 (6,821)
64 electric lines	74,516,171	342,931 (337,515)

Of the fifteen cable railways, eight were running during the whole year, the others during the season only (three to nine months, generally five months).

The mean utilization of the passenger accommodation provided on the electric main and secondary lines was 27 per cent, as againt 26·9 on the steam railways. Each passenger travelled on the average 6·4 kilometres (4 miles) on the electric main and secondary lines, and 25 kilometres (15·5 miles) on the steam railways. The highest figures in this respect, were of course obtained on the standard gauge lines of Burgdorf-Thun and Freiburg-Ins (11·34 and 12·58 kilometres [7·05 and 7·82 miles] respectively). On the steam railways, the highest averages were 48·9 kilometres (30·4 miles) St. Gothard, 29·52 kilometres (18·34 miles) Visp-Zermatt, 21·3 kilometres (13·2 miles) Berne-Neuchatel, and 20·97 kilometres (13·03 miles) Federal Railways.

The total receipts (passengers, goods, luggage, miscellaneous) of the electric main and secondary railways varied between 5,062 and 23,527 francs per kilometre (between £325.18*s.* and £1,514.10*s.* per mile); that is excluding the two mountain lines proper, the Gornergrat line and the Jungfrau line, where the conditions are exceptionally favourable. The receipts of these two lines were 30,364 and 60,464 francs per kilometre (£1,954.12*s.* and £3,892.4*s.* per mile) respectively. The average receipts of all the main and secondary railways (both steam and electric) were 38,717 francs per kilometre (£2,492.7*s.* per mile); but this high average is chiefly due to the exceptional yield of some of the lines, such as the St. Gothard (84,117 francs per kilometre [£5,414.17*s.* per mile]), the Federal Railways (45,695 francs per kilometre [£2,941.10*s.* per mile]) and several of the mountain lines proper.

In the case of the electric tramways, the receipts per kilometre varied between 3,387 and 66,474 francs (between £218.1*s.* and 4,279.2*s.* per mile), with an average of 33,590 francs (£2,162.6*s.* per mile); the two horse tramways had receipts of 826 and 3,545 francs per kilometre (£53.4*s.* and £228.4*s.* per mile). In the case of the electric cable railways, the receipts per kilometre varied between 15,907 and 243,031 francs (between £1,024 and £15,644.11*s.* per mile). The average for all the cable railways, both electric and hydraulic, was 59,967 francs per kilometre (£3,860.5*s.* per mile).

The working expenses of the main and secondary railways are shown in table IV, in percentages of the working expenses proper. Column *b* includes the cost of maintenance and renewal of the line, including the wages of employees required for this purpose, column *d* the traction, employees, fuel and stores for locomotives and cars, maintenance and renewal of rolling stock (column *g*). The total expenditure (*f*) includes, besides the working expenses proper (*e*) the " miscellaneous expenses " such as rents, rates, etc.

The total expenses on the main and secondary railways varied between 3,600 and 24,036 francs per kilometre (between £231.15*s.* and £1,547.6*s.* per mile); on the electric tramways between 3,117 and 46,094 francs per kilometre (between £200.14*s.* and £2,967.3*s.* per mile); on the

Table IV. — Working expenses of electric main and secondary lines.

Index number.	LINE (MAIN AND SECONDARY RAILWAYS).	*a*	*b*	*c*	*d*	*e*	*f*	*g*
		EXPENDITURE, IN PERCENTAGES OF THE WORKING EXPENSES PROPER (column *e*).				Working expenses proper per kilometre (per mile) of track, in francs.	Total expenses per kilometre (per mile) of track, in francs.	Maintenance and renewal of rolling stock, in percentages of the cost of traction (column *d*).
		General management.	Maintenance and supervision of track.	Train and station service.	Traction.			
1	Burgdorf-Thun.	8·44	24·85	28·93	37·38	8,203 (£528)	9,601 (£618.1*s.*)	28·92
2	Freiburg-Murten-Ins	9·98	18·04	25·72	46·26	6,045 (£389.3*s.*)	6,561 (£422.7*s.*)	16·47
3	Orbe-Chavornay	1·75	36·16	25·03	37·06	8,973 (£577.12*s.*)	9,839 (£633.7*s.*)	9·81
4	Aarau-Schöftland	8·31	12·42	22·24	57·03	4,913 (£316.5*s.*)	5,253 (£338.2*s.*)	29·61
5	Aigle-Leysin	9·15	17·86	20·85	52·14	11,044 (£710.18*s.*)	11,710 (£753.16*s.*)	29·40
6	Bex-Gryon-Villars	4·53	16·55	21·78	57·14	5,410 (£348.5*s.*)	6,229 (£400.19*s.*)	25·48
7	Bremgarten-Dietikon	8·66	17·17	33·03	41·14	4,905 (£315.15*s.*)	5,263 (£338.15*s.*)	16·26
8	Châtel-Bulle-Montbovon	7·63	17·94	30·74	43·69	4,349 (£279.19*s.*)	4,556 (£293.6*s.*)	11·04
9	Châtel-Palézieux	8·55	13·90	26·66	50·89	7,095 (£456.14*s.*)	9,443 (£607.17*s.*)	14·31
10	Geneva-Veyrier	5·81	11·76	14·75	67·68	13,343 (£858.18*s.*)	15,095 (£971.14*s.*)	12·69
11	Grütschalp-Mürren	12·26	27·34	22·78	37·62	7,231 (£465.10*s.*)	8,718 (£561.3*s.*)	32·41
12	Lauzanne-Moudon and Savigny	17·17	13·55	22·15	47·13	4,235 (£272.12*s.*)	4,564 (£293.16*s.*)	12·76
13	Montreux-Berner Oberland	9·98	20·91	31·99	37·12	5,860 (£377.4*s.*)	7,198 (£463.6*s.*)	10·49
14	St-Gallen-Speicher-Trogen	8·66	16·70	27·39	47·25	12,726 (£819.4*s.*)	13,288 (£855.7*s.*)	28·32
15	Sissach-Gelterkinden.	3·50	25·51	29·40	41·59	9,618 (£619.2*s.*)	9,835 (£633.2*s.*)	45·32
16	Stanstad-Engelberg	9·41	36·41	24·40	29·78	5,963 (£383.16*s.*)	6,804 (£438)	23·41
17	Vevey-Chamby	9·55	6·23	30·27	53·95	4,881 (£314.4*s.*)	5,143 (£331.1*s.*)	16·22
18	Wetzikon-Meilen	7·19	8·09	22·79	61·93	3,503 (£225.9*s.*)	3,600 (£231.15*s.*)	4·03
19	Gornergrat	21·98	24·67	18·01	35·34	7,659 (£493)	10,319 (£664.5*s.*)	20·82
20	Jungfrau.	9·88	13·34	27·60	49·18	9,959 (£641.1*s.*)	12,786 (£1,547.6*s.*)	38·20

electric cable railways between 12,850 and 161,017 francs per kilometre (between £827.4*s*. and £10,365.2*s*. per mile)

The coefficient of working (proportion, per cent, of working expenses to receipts) is given, in column *k* of table I, for all the electric railways. The mean values are as follows :

Main and secondary lines, electric	71·42 per cent.
— — — à vapeur	61·37 —
All the main and secondary lines	64·20 —
Tramways, electric	74·00 —
— horse	109·90 —
All the tramways	76·52 —
Cable railways, electric	60·38 —
— hydraulic	47·68 —
All the cable railways	53·84 —

The coefficient of working is thus higher in the case of the electric lines than in that of the steam lines. If we compare the values of the coefficients of working of the main and secondary lines in percentages of the number of railways we obtain the following results :

Of the 51 steam railways.	Of the 20 electric railways.	Have a coefficient of working of
3·9 per cent.	10 per cent.	Less than 40 p. c.
5·9 —	5 —	40 to 50 p. c.
15·7 —	5 —	50 to 60 —
21·6 —	35 —	60 to 70 —
15·7 —	15 —	70 to 80 —
17·7 —	10 —	80 to 90 —
3.9 —	15 —	90 to 100 —
8·0 —	0 —	100 to 120 —
4·0 —	5 —	120 to 140 —
2·0 —	0 —	More than 140 p. c.

If we compare the working expenses proper of the electric main and secondary lines with those of the steam lines, we find that the mean per kilometre is 7,299 francs (£469.17*s*. per mile) in the case of electric traction and 28,544 francs (£1,837.9*s*. per mile) in that of steam traction. In this case also, it must be remembered that the high mean in the case of the steam railways is largely due to several cases where the working expenses per kilometre are exceptionally high, such as the St. Gothard with 41,607 francs (£2,678.8*s*. per mile), the Federal Railways with 27,431 francs (£1,765.16*s*. per mile), the Pilatus with 29,121 francs (£1,874.12*s*. per mile) and the Rigi with 28,596 francs (£1,840.16*s*. per mile). Nevertheless, the fact remains that of the fifty-one steam railways, there are thirty-two (*i. e.*, nearly two-thirds) on which the working expenses per kilometre are higher than the average on all the electric railways, which is 7,300 francs (£469.17*s*. per mile). The lowest working expenses (*see* column *e* of table IV) in the case of electric traction are 3,502 francs per kilometre (£225.9*s*. per mile) Wetzikon-Meilen), and 3,627 francs (£233.10*s*. per mile) in that of steam traction (Rigi-Scheidegg). On the fifty one secondary lines and the twenty electric lines, the working expenses per kilometre are below 7,300 francs (£469.17*s*. per mile) on 37 per cent of the steam lines and on 60 per cent of the electric lines; they are below 6,250 francs (£402.7*s*. per mile) on 27·5 per cent of the steam lines and on 50 per cent of the electric lines. This shows that the working expenses proper are generally lower in the case of electric traction than in that of steam traction.

In looking at the subject from the economic point of view, however, it is necessary also to take into consideration the cost of construction per kilometre (*see* above). The mean cost of construction, per kilometre, for the different gauges was as follows :

27 steam lines, standard gauge	201,237 francs	(£12,954. 4*s*. per mile).
16 — metre (3 ft. 3 $^3/_8$ in.) gauge	115,022 —	(£7,404. 6*s*. —).
8 — rack only	313,552 —	(£20,184. 4*s*. —).
3 electric lines, standard gauge	128,380 —	(£8,264. 3*s*. —).
15 — metre (3 ft. 3 $^3/_8$ in.) gauge	134,757 —	(£8,674.14*s*. —).
2 — rack only	663,260 —	(£42,695.15*s*. —).

Thus in the case of standard gauge lines, the average cost of construction of the electric lines is much lower, whereas in the case of metre (3 ft. 3 $^3/_8$ in.) gauge lines it is somewhat higher, particularly if we consider that the electric secondary lines of metre gauge are laid as a rule not on a separate roadbed, but on the public highways. The high cost of the two electric rack railways (Gornergrat and Jungfrau) is due to exceptional difficulties in their construction, rather than to the fact that they are equipped with electric traction.

Speaking generally, the principle that electric traction, as a rule, involves greater initial outlay but reduced working expenditure is confirmed by the Swiss lines.

It would be of special interest to tabulate, for purposes of comparison, the data referring to steam traction and to electric traction, those referring to electric traction being divided into two classes, representing continuous and three-phase current respectively. As regards electric traction, good subjects for comparison are the two standard gauge main lines of Burgdorf-Thun (three-phase current) and of Freiburg-Murtens-Ins (continuous current, third rail). It is more difficult to make a suitable choice in the case of steam railways, as they are operated under much more varied conditions. The Emmenthal line, 42 kilometres (26 miles) long, is fairly suitable, as both as regards traffic and working it most resembles the two electric lines mentioned ; then also the Burgdorf-Thun line is operated, for the owners, by Emmenthal employees.

The particulars and the results of these three typical examples of steam traction, of three-phase current traction and of continuous current traction are given in table V ; from this we may at once draw the resulting conclusions.

The rate of interest earned by the Swiss electric lines, like that earned by the Swiss railways generally, is not satisfactory. The share capital of all the main and secondary railways returned 3·284 per cent ; the steam lines 2·086 and the electric lines 2·353 per cent (*see* also table I, column 1). The shares of the twenty-nine electric tramways yielded, on the average, only 1·4 per cent, and of the electric cable lines, only 1·79 per cent.

The rate of interest on loans varied between 2·5 and 5 per cent, the average being

4·33 per cent in the case of electric standard gauge lines,
4·23 — — — metre (3 ft. 3 $^3/_8$ in.) gauge lines,
4·50 — — — rack railways,
4·10 — — — tramways,
4·21 — — — cable railways.

The following table shows what proportion of the total capital is in the form of loans and shares respectively :

	Loans.	Shares.
Electric lines, standard gauge	28·5 per cent.	71·5 per cent.
— — metre (3 ft. 3 $^3/_8$ in.) gauge	25·5 —	74·5 —

Table V.

—

Comparison of steam traction and electric traction.

Year 1903.	Steam. (Emmental line.)	Three-phase current. (Burgdorf-Thun.)	Continuous current. (Freiburg-Murten-Ins.)
Length open, kilometres (miles)	42·3 (26·3)	40·2 (25)	32·3
Average gradient, per mil	6·1	12·00	9·51
Maximum — —	15	25	30
Train-kilometres (train-miles) (passengers and goods)	246,848 (153,387)	277,437 (172,394)	164,883 (102,455)
— paying, per kilometre of line	5,851	7,314	6,164
Daily trains over whole line	15·99	18·86	15·58
(Of these, passenger trains)	(13·9)	(15·8)	(15·3)
Axle-kilometres (passengers), per kilometre of line	29,229	33,971	25,481
Number of passenger cars (motor cars included)	18	22	10
Total passenger accommodation	1,065	810	296
Horse-power (British horse-power) of each motor car (or locomotive)	189 (186)	262 (258)	300 (296)
Passenger-kilometres, per kilometre of line	179,923	143,228	80,780
— — per train-kilometre	35·4	24·8	14·4
Mean utilization of passenger accommodation, per cent	25·8	22·9	23·3
Goods, ton-kilometres per kilometre of line	69,801	33,987	33,935
Total cost of construction, per kilometre (per mile) of line, francs	142,904 (£9,199.2*s.*)	158,981 (£10,234.1*s.*)	104,780 (£6,744.19*s.*)
Divided as follows :			
Roadbed	39,523 (£2,544.3*s.*)	39,711 (£2,556.6*s.*)	27,684 (£1,782.1*s.*)
Superstructure	31,623	29,104	22,933

Rolling stock	21,853 (£1,406.14s.)	21,163 (£1,362.6s.)	8,155 (£524.19s.)
General expenses, including interest during construction	10,995 (£707.16s.)	6,755 (£434.17s.)	3,986 (£256.12s.)
Working expenses proper, per kilometre (per mile) of line	10,264 (£660.14s.)	8,203 (£528)	6,045 (£389.3s.)
— — — per train-kilometre (per train-mile)	1·76 (2s.3·23d.)	1·19 (1s.6·35d.)	1·06 (1s.4·42d.)
— — — per paying train-kilometre (per paying train mile)	1·75 (2s.3·04d.)	1·11 (1s.5·18d.)	0·98 (1s.3·06d.)
Total expenses, per kilometre (per mile) of line	11,928 (£767.16s.)	9,601 (£618.1s.)	6,561 (£422.7s.)
Coefficient of working (ratio of expenses to receipts, per cent)	67·45	83·41	93·59
Expenses per kilometre (per mile) of line :			
General management, in francs	705 (£45.8s.)	691 (£44.10s.)	604 (£38.17s.)
Maintenance and supervision of line, in francs	3,263 (£210)	2,038 (£131.3s.)	1,090 (£70.3s.)
Train and station service, in francs	2,884 (£185.13s.)	2,373 (£152.14s.)	1,555 (£100.2s.)
Traction, per kilometre (per mile) of line, in francs	3,411 (£219.12s.)	3,099 (£199.9s.)	2,796 (£180)
— per paying train-kilometre (per paying train-mile), in francs	0·580 (8·96d.)	0·420 (6·49d.)	0·450 (6·95d.)
Fuel and stores for locomotives and rolling stock, percentage of cost of traction	46·23	43·71	63·42
Maintenance and renewal of rolling stock, percentage of cost of traction	18·12	28·92	16·47
Receipts :			
Passengers, in francs per kilometre	6,926 (£445.17s.)	5,195 (£334.8s.)	3,149 (£222)
Per train-kilometre (per train-mile), in francs per kilometer	1·360 (1s.9·01d.)	0·900 (1s.1·90d.)	0·620 (9·58d.)
Per passenger, in francs	0·380 (3·65d.)	0·410 (3·94d.)	0·540 (5·18d.)
— per kilometre (per mile), in centimes	3·85 (0·595d.)	3·64 (0·562d.)	4·28 (0·660d.)
Total, per kilometre (per mile) of line, in francs	17,683 (£1,138.5s.)	11,510 (£740.19s.)	7,010 (£451.5s.)
— per paying train-kilometre (per paying train-mile), in francs	3·020 (3s.10·66d.)	1·830 (2s.4·27d.)	1·140 (1s.5·61d.)
Staff :			
Total active staff	171	119	66
Per kilometre (per mile) of line	4·04 (6·50)	2·95 (4·75)	2·04 (3·28)
Per 10,000 francs (£400) of total receipts	2·29	2·57	3·25

	Loans.	Shares.
Electric lines, rack	48·2 per cent.	51·8 per cent.
— tramways	14·3 —	85·7 —
— cable railways	43·5 —	56·5 —

Most of the loans are in the form of debentures.

In one case only has any electric line received any subvention : the canton of Neuchatel gave one of 130,000 francs (£5,200) to the Val-de-Ruz tramway, which has a share capital of 350,000 francs (£14,000).

The shares issued are, as a rule, of 500 francs (£20) in the case of electric main and secondary lines, of 100, 200, 250, 400 and 500 francs (£4, £8, £10, £16 and £20) in that of tramways, and of 100, 250 and 500 francs (£4, £10 and £20) in that of rack railways.

CONCESSIONS. — STAFF. — ACCIDENTS.

The concessions for most of the electric lines are for a period of eighty years, but shorter concessions are not rare. Of the twenty electric main and secondary lines, fourteen have concessions for eighty years, two for seventy-five and seventy-eight, four for fifty; of the twenty-nine electric tramways, fourteen have concessions for eighty years, ten for fifty and five for fifty-eight to seventy. The electric rack railways have as a rule concessions for eighty years. The Confederation cannot buy up the lines till at least thirty years after they have been opened to traffic.

The total number of the employees is given in the following table :

All the main and secondary lines	33,045
Electric — — —	802
All the tramways	2,277
Electric tramways	2,273
All the cable railways	274
Electric cable railways	133

The number of employees per kilometre of line is as follows :

Main and secondary lines, electric	2·64	(4·25 per mile).
— — — steam	8·5	(13·7 —).
Tramways, electric	6·08	(9·78 —).
— horse	4·0	(6·4 —).
Cable railways, electric	8·9	(14·3 —).
— hydraulic	14·1	(22·7 —).

On the main and secondary lines, these employees may be divided into the following classes :

	Per kilometre (per mile) of line.
General management	0·17 (0·27)
Maintenance and supervision of track	0·73 (1·17)
Station and train service	0·89 (1·43)
Workshops and traction	0·85 (1·37)

Accidents : in 1903, there were on the electric main and secondary lines 32 accidents, or 10·9 per 100 kilometres (17·5 per 100 miles) of line (5 derailments, 2 collisions, 25 miscellaneous). The total number on the steam main and secondary lines was 1,112 accidents, or

29·4 per 100 kilometres (47·3 per 100 miles) of line. The number of victims, on the electric main and secondary lines, was 26 (2 killed, 24 injured); of these 9 were passengers (1 killed, 8 injured), 12 employees (all injured) and 5 other people (1 killed, 4 injured). Thus accidents on electric main and secondary lines were responsible, per million of passengers, for 0·3 passenger killed and 2·41 passengers injured, as against 0·31 killed and 1·28 injured on steam railways; per million train-kilometres, there were 6·7 railways servants injured (10·8 railways servants injured per million train-miles) (0 killed) on electric lines, as against 0·77 killed and 2·8 injured (1·24 killed and 4·5 injured per million train-miles) on steam railways. As regards other people, there were, per 100 kilometres of line, 0·34 killed and 1·34 injured (0·55 killed and 2·16 injured per 100 miles) on electric lines, and 0·82 killed and 0·53 injured (1·32 killed and 0·85 injured per 100 miles) on steam railways. There were 170 accidents on the electric tramways (26·7 per 100 kilometres [43 per 100 miles] of line), with 7 killed and 145 injured; per million car-kilometres (motor cars on electric tramways) there were 0·37 killed and 7·7 injured (0·60 killed and 12·4 injured per million car-miles), or, per million passengers, 0·1 killed and 2·08 injured. As an instance we may quote the Berlin tramways : there were 5·39 victims of accidents per million passengers, namely 0·57 passenger killed or seriously injured, and 4·82 slightly injured.

The total number of accidents on the Swiss cable railways was 1 (1 passenger injured).

[621 .158.5]

THE CAR OF LOCOMOTIVE BOILERS AT TERMINALS AND WHILE IN SERVICE (1),

By F. P. ROESCH,

CHAIRMAN COMMITTEE ON CARE OF LOCOMOTIVE BOILERS.

(*Engineering News.*)

In order to learn which of the methods [of caring for boilers] most commonly used approach nearest the ideal, and at the same time held the engine out of service the least time, the following questions were sent out :

1° Average number of miles per locomotive per month, freight and passenger. The object in asking this question was to obtain data for calculating the earning capacity of the locomotive and to determine the probable loss in mileage due to engine being held for washing the boiler.

The replies received varied all the way from 2,200 to 5,300 miles for freight, and from 3,000 to 9,500 for passenger engines. The high mileage was invariably on roads having good water.

2° Average miles between washouts? From 500 to 50,000.

3° Average time consumed washing boilers? Two to ten hours. Personally, I do not think the two-hour man did a good job.

4° Average cost of washout? 37 cents to $8·50.

5° Average life of fire-box? Of flues? From two years to twenty for fire-box, and from six months to ten years for tubes.

6° Method used in cooling down and washing boiler? From no particular method to the ideal way of slow cooling and washing and filling with hot water.

7° Are boilers washed regularly, etc.? Some do, others do not.

8° Have you used soda ash or other chemicals in feed-water? If so, with what results?

To this question several replies were received, but the reply received from Mr. J. F. Roddy, of the Santa Fe [to this and the other questions asked — Ed.] is in itself such an excellent treatise on the care of locomotive boilers and contains so many other valuable features and pertinent remarks that it is given in full [condensed here — Ed.].

EXPERIENCE ON THE SANTA FE.

" Sir : With the able assistance of our general boiler inspector, Mr. George Austin, I submit the following in answer to the list of questions relative to the care of locomotive boilers at terminals and while in service.

" 1° Average number of miles per locomotive per month — Freight service, 3,000 ; passenger service, 5,000.

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(1) Condensed from report submitted at the annual meeting of the Traveling Engineers' Association, Chicago, August, 1906.

" 2° Average miles between washouts — Cannot give you anything definite. Governed by service and water conditions.

" 3° Average time consumed from time engine arrived at cinder pit to time engine is again ready for service after being washed out, seven hours.

" 4° Average cost of washout, 70 cents.

" 5° and 6° Average life of fire-box — Cannot give you anything definite, as owing to water treatment the life of fire-boxes is being extended so that it is impossible at this time to give definite information. Average life of set of tubes — Passenger service, eighteen months to two years; freight service, twelve to eighteen months. This varies according to the different divisions and service. The water treatment has also introduced in the case of the flues a question as to the average life, it having prolonged the period of successful service of the flues to such an extent that I cannot give more definite information at this time.

" 7° Boilers are washed regularly, and a record of each washing and place at which washed, together with the name of the boiler washer, is placed on a card and placed in the cab.

" We are treating water in track tanks with soda-ash and lime, this treatment being directly under the supervision of our chief chemist, Mr. Powers, who is the originator of the system of treated water now in use on the Santa Fe. The average life of flues before water treating was six months, and many failures occurred during that time. I will here state that during the year 1905, we had three months without a failure from leaky flues on the middle division of this system, which seems remarkable, compared with the average performance previous to water treatment, where in many cases the number of flue leaks would aggregate from forty to fifty. We are now running our flues in passenger service eighteen months to two years, and in freight service twelve to eighteen months, with at least one-tenth the failures we had previous to water treating. Our side-sheets have stopped cracking and corrugating. Stay-bolts have ceased leaking, *i. e.*, to the extent of being a serious proposition. Very few half side-sheets are applied — in fact, so far as injury to fire-boxes is concerned there is nothing in comparison to conditions that prevailed previous to water treating.

" The prominent feature of water treating which is considered an adverse feature, is the increased foaming. This is being met by judicious use of blow-off coks and the use of Dearborn boiler compound.

" We explain to our men that the water in a boiler that is foaming, is concentrated to about 200 grains of alkali to the gallon, and when foaming begins it is impossible to stop it until this concentration has been reduced below the foaming point. This can only be done by blowing out or working out through the engine, a quantity of water and replacing it with sufficient clean water to bring the average concentration below the foaming point, then the foaming will cease.

" While it may look like a step backward, it is the opinion of the writer that a surface cock, coupled to a perforated pipe in the boiler, conveniently located above the crown sheet, and to be used as an auxiliary to a blow-off cock located at the lower part of the back head, would materially assist in overcoming the foaming condition, and would be the best possible location for these devices, the surface cock to be used only when not much sludge is present, it being understood that the water is concentrated, so far as foaming matter is concerned, heavier at the top than it is at the bottom. This is explained by the fact that the water being put in by the injectors, being of a lower temperature, goes to the bottom, and is, except for the sludge, so far as foaming matter is concerned, purer than the water above. It would seem then logical, in view of the above conditions, that blowing out from the surface would get out the most foaming matter, and we are all familiar with the fact, that in alkali waters that carry other solids, the top water in the glass frequently shows the presence of large quantities of solids, which appear to be floating on the surface, and which the surface blow-off cock would remove. It would enable you to retain your fresh water in the boiler while overcoming a foaming condition, while on the other hand, to overcome a foaming condition with the blow-off cock at the mud ring, you would necessarily have to blow out a large amount of fresh water that had just been applied. The writer has had considerable experience with the surface blow-off cock, and with very satisfactory results.

" Our aim is to keep the blow-off cocks in first-class working condition, and with a good working blow-off cock, he is a very poor engineer who makes a failure on account of foaming, or works the foaming water through the engine — that is to say, with ordinary water conditions. Our conditions as to foaming are showing steady improvement, as our men become educated in the use of the blow-off cock. We have men who will run 1,600 miles without asking for a washout, and more are slowly falling into line; while others in the same service with the same class of engine, want a washout or water changed each trip. This is self-explanatory — one man is interested and an engineer; the other is neither.

" Another fact in connection with the foaming proposition in my experience on this railroad, and one worthy of consideration, and which is borne out by our records, is that we had just as much foaming previous to water treatment as now, had just as many failures, and the work the engines were required to do was not nearly as heavy as at present. But before water treating, the boiler washer was blamed for foaming; now it is the soda ash.

" Speaking of boiler washing, I will say here that previous to water treating, we washed boilers frequently to get rid of scale, an impossible proposition, as evidenced at that time by leaky fire-boxes and flues. Now, washing out is an easy proposition — some sludge and a little scale. The scale now does very little injury, as compared with what it did before water treatment. We get our boilers clean now in a few minutes' washing, while previous to water-treating there was no such a thing as a clean boiler that had been in service three months.

" We first began treating water on the Santa Fe system about three years ago. We have now in operation on the Eastern Grand Division, which includes the territory between Chicago and Purcell, Ind. T., 34 treating plants, and these plants, as before stated, are under the immediate charge of the chief chemist, Mr. Powers, who gets a sample of the waters treated each week, and which are analyzed, and treatment varied accordingly. These treating plants are divided into districts, and each district has an assistant chemist in charge, who makes two or three visits each week to each plant, keeping close check on the conduct of each treating station. I understand that Mr. Powers treats the water at an expense of about 3 cents per 1,000 gallons.

" The kind of blow-off cock in use on het Santa Fe Railway, is a gate valve, operated with levers conveniently arranged to be operated by hand. This in another proposition we are improving upon. We are trying to get these devices arranged as conveniently as possible for the enginemen to work, and pipe them so that the proximity of cars or buildings or the direction of the wind, will not interfere with their operation, whether the engine is moving or not. Our blow-off cocks are usually located near the mud ring, at front and back end of fire-box, in the side sheets. From our earliest recollection, it has been the custom of engine builders to apply blow-off cocks. These have been applied more for the convenience of boiler washers than for any assistance they might be to the enginemen while on the road. Such being the case, but little care has been given as to the location of the cocks or of the operating devices. As we gain in experience in our knowledge of the benefits of blowing out, conditions are changing. It is now being realized that the blow-off cock, properly located and conveniently arranged for working, is one of the most useful devices we have on the modern engine.

" The proper use of the injector is an important factor in the care of locomotive boilers. It is common practice at roundhouses, to set out engines with a heavy fire in them and fill the boiler full of water, before or after setting out, to prevent popping off. The particular adverse feature of this plan, and which I particularly desire to explain, is that when water is put into a boiler while the engine is standing, the only reduction made in the steam pressure is the quantity of steam used to operate the injector during the process.

" The care of the boiler, both on the road and at terminals, simply means the application of common sense, and that each one having in charge or the direction of the care of these boilers shall understand a few simple propositions. The boilermaker should see to it that his flues are tight and clean, not with that degree of tightness that is frequently allowed to be let go with the understanding that it will take up when hot, but that the flues must be absolutely tight — not a sign of a leak from them. That the grates shall be in free working condition. That the blow-off cocks and injectors shall be in good order and conveniently located. The engine crew should understand that the preservation of the efficiency of the boiler depends largely on two propositions :

" 1° Pressure should be carried as nearly uniform as practicable; even temperature by careful firing and use of injectors.

" 2° Keep the boiler as clean as possible by free use of blow-off cocks.

" The engineer with average good flues and other good conditions mentioned and following out suggestions as to equal temperature and keeping boiler clean, will seldom fail to give good results from his handling, and it must be a source of satisfaction to those who send out engines in that condition to have performances that will compare with any performance on any railroad so far as successful operation of power and prevention of engine failures is concerned.

" Yours truly,
" J. F. Roddy, *road foreman of engines.* "

SUMMARY OF REPLIES RESUMED.

9° What experience with Kennicott water softener?

10° What kind of blow-off cocks, etc.?

11° Have you had any experience with Talmage device or Talmage system of cleaning boilers, etc.?

The ninth and eleventh questions were asked to bring out arguments for or against chemical or mechanical treatment of water. Replies to ninth question were : No railway replying was using the system at all tanks, consequently none were in position to give definite data; where it was used, however, all reports were in favour of it, as by this system of purifying the water the life of the boiler tubes was increased 30 per cent, while failures due to leakage were reduced in like ratio. One strong argument in favour of the Kennicott system was that it required little, if any, care; all that was necessary was to instal the plant, and have an intelligent man look after it. It is to be regretted that no more full and definite information with regard to this system was brought out.

To the question with regard to blow-off cocks, replies were received showing that every known blow-off cock from the old plug to the most elaborate automatic is in use. It is apparent from these replies that mechanical men do not realize the important part played by the blow-off cock in the care of the boiler. The blow-off cock is half the battle. What we need first of all in the proper care of boilers is a first-class, reliable blow-off cock — one that opens easily and is seated by pressure in the boiler; one that is not continually leaking, and having removable seats that can be renewed with little trouble and less expense; one that the engineer is not afraid to open on the road, as he knows he can depend upon it. He cannot afford to take chances with an unreliable article and will not do it; therefore, if you are dependent upon your engineers for blowing out boilers on the road, give them a good blow-off cock, if you expect them to use it.

To the eleventh question, but four replies were received, all, however, highly favourable towards the Talmage system. The following is a brief synopsis: Miles between washouts with Talmage system, 5,000; without, 800. Cost and duration of washouts, same with or without. Life of tubes with Talmage system increased 35 per cent. Engine failures and boiler repairs decreased 58 per cent. Earning capacity of locomotive increased where engines are pooled, 22 per cent; where not pooled, 8 per cent. Foaming and priming entirely eliminated, regardless of the kind of water used. Cost of original installation, if increased earning capacity is taken into consideration, saved in thirty to sixty days. Cost of operation about 22 cents per 100 miles. Maintenance cost, practically nil.

As all may not be familiar with this system, a brief description may be in order. The Talmage system of caring for boilers, is entirely mechanical. It consists, first, of a series of perforated pipes placed in the belly of the boiler, over the crown-sheet, and in the leg, about 8 inches above the mud ring. Each pipe is connected to a blow-off cock, which is seated by the pressure in the boiler. On the boiler-head is placed a large sight-feed lubricator holding about 1 $^1/_2$ gallons of oil. This lubricator is tapped into the boiler-head below the water level, and the oil (a special distillate called Rubra oil) is fed directly into the water, mixing with it, and precipitating the solids to the bottom in the form of oily mud. So well does the oil perform its work, that flues after one year's service have a coating of scale not much thicker than ordinary writing paper. All the mud collected in the boiler is blown out at the end of each trip through the blow-off cocks. The boiler is washed out once in twenty or thirty days. On one road, with which I was connected, where this system was in use, the engines so equipped were run 5,000 miles between washouts, while those not equipped were washed every 700 miles. When it comes to care of locomotive boilers in service and at terminals, I know of no other method that will come nearer combining the good features of the ideal and at the same time eliminating the objectionable features, than the Talmage system.

[621 .131.1]

ACCELERATION, AND SOME LOCOMOTIVE PROBLEMS (¹),

By William G. RAYMOND.

(Railroad Gazette.)

There are certain locomotive problems of interest to the railroad locating and maintenance engineer, which involve the tractive power of the locomotive, train resistance, and the general principles of accelerated motion.

The most important of these problems are :

1° To determine the load a given locomotive can haul on a given grade at a given constant velocity ;

2° To determine the distance on a given grade required by a given locomotive with a given load, to increase or diminish its speed from one given velocity to another ;

3° The time required to produce this change in velocity ;

4° The converse of 2° to determine what velocity can be acquired by a given locomotive with a given load in a given distance, on a given grade ;

5° To determine the length of grade steeper than that for which a locomotive is loaded that can nevertheless be ascended by the aid of a run at the hill. This is the problem of velocity or momentum grades ;

6° To determine the speed of a given locomotive with a given load throughout a given division of track ;

7° To specify the principal features of the locomotive to be purchased for a given service.

In all these problems, certain data which in the nature of the case are to some extent indeterminate must be assumed to be exactly known, and certain other conditions must be assumed that in reality never exist, with the result that practically all of the determinations are approximate and must be considered to be of the nature of carefully prepared estimates. This is particularly true in developing formulæ applicable to different locomotives for which the several constants have not been determined by road tests.

Acceleration.

Accelerated motion plays an important part in practically all of these problems, and there follows a brief statement of principles and the development of working formulæ.

(¹) Reprinted by permission from *The Transit.*

By the property of inertia, all bodies tend to stay in that condition of motion in which at any instant they may be. An accelerating, retarding or deviating force must be applied to change the condition of motion as to velocity or direction.

It is known that a constantly applied force of given magnitude will produce a uniformly changing condition of motion. The rate of change is called the acceleration and may be positive or negative (retardation). It is known also that the acceleration of a given mass is proportional to the magnitude of the constant unbalanced force acting. Thus, if w be the weight of a body, *i. e.*, the measure of the force of gravity acting on it, and g be the acceleration due to gravity, and if P be any other force applied to the body, the acceleration a, produced by P, will be given by

$$a = \frac{P}{w} g \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

from which the force P necessary to produce the acceleration a in a body of weight w is

$$P = \frac{wa}{g} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

Under the influence of the force of gravity, the velocity of a falling body increases g feet per second, g having a value varying with the distance from the center of mass of the earth and with latitude, but usually assumed for mechanical problems as 32·16. If the body start from rest, it will have a velocity of g feet at the end of the first second, its average velocity for the first second will therefore be $\frac{g}{2}$ feet, which will also be the space covered in the first second. At the end of t seconds, the velocity will be tg feet per second, the average velocity will have been $\frac{tg}{2}$, and the space passed over will therefore be $\frac{tg}{2} \times t = \frac{t^2 g}{2}$ feet. If v be velocity in feet per second, t be time in seconds, and h the space or height of fall,

$$v = gt \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (3)$$

$$h = \frac{gt^2}{2} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (4)$$

Since from (3) $t = \frac{v}{g}$, substitution in (4) gives

$$h = \frac{v^2}{2g} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (5)$$

Perfectly analogous to these equations, if P be a ferce acting on a body and producing an acceleration of a feet per second, for t seconds, covering a space of l feet

$$v = at \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (6)$$

$$l = \frac{at^2}{2} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (7)$$

$$l = \frac{v^2}{2a} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (8)$$

If a body be uniformly accelerated in a distance of l feet from rest to a velocity of v feet per second, the acceleration from (8) is

$$a = \frac{v^2}{2l} \quad \ldots \ldots \ldots \ldots \quad (9)$$

and the force P necessary to produce this acceleration, given by substituting for a in (2), its value from (9), is

$$P = \frac{wv^2}{2gl} \quad \ldots \ldots \ldots \ldots \quad (10)$$

If the velocity is expressed in miles per hour V

$$v = \frac{5280V}{3600}$$

and

$$P = \frac{w}{2gl} \times \left(\frac{5280V}{3600}\right)^2$$

and if the weight is expressed in tons W of 2,000 lb.

$$w = 2{,}000W$$

and

$$P = \frac{66{\cdot}9WV^2}{l} \quad \ldots \ldots \ldots \ldots \quad (11)$$

If a train be the body, P is the tractive effort to be exerted by the locomotive to produce the velocity of V miles per hour in the distance of l feet.

But not only is the train given a velocity of translation, the wheels are given a velocity of rotation, requiring P to be larger than indicated by the foregoing expression by an amount depending on the relative masses of car and wheels, the pattern of the wheels and the velocities. For any given set of conditions, the addition to P may be determined by comparing the energy required to accelerate the car wheels in their motion of rotation with that required to give the resulting motion of translation to the car as a whole. No great precision can be attempted for a general formula. The increase of P may be as little as 2 1/2 per cent, and it may be as high as 6 or 8 per cent over that given by equation (11). Adopting 4·63 per cent for simplicity of result

$$P = 70\,\frac{V^2}{L}\,W. \quad \ldots \ldots \ldots \ldots \quad (12)$$

This force P must be in excess of the forces necessary to overcome all other resistances. It is probable that no train is uniformly accelerated from rest to any given velocity it may attain, because from a velocity of 0 + to 5 or 6 miles an hour the pull an engine exerts is nearly constant and is the tractive effort of adhesion (1), while the resistances to motion rapidly decrease, leaving an increasing portion of the tractive effort for acceleration. When the velocity of 5 or 6 miles is exceeded, the resistances to motion slowly increase, the tractive effort decreases, and there results a decreasing force available for acceleration, decreasing somewhat more rapidly than in proportion to the increase of velocity.

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(1) This statement may be questioned. The Pennsylvania Railroad testing department, in its estimates of maximum tractive effort of simple locomotives, counts on only 80 per cent of the boiler pressure as available in the cylinders even at minimum speeds. If this allowance is correct, probably

If the velocity is to be increased from V_1 miles per hour to V_2 miles per hour, the force required is

$$P = 70 \frac{W}{l} (V_2^2 - V_1^2) \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (A)$$

If the force be known, and it is desired to determine the distance required to increase the velocity from V_1 to V_2 miles per hour,

$$l = 70 \frac{W}{P} (V_2^2 - V_1^2) \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (B)$$

If the distance and available force are known, and it is desired to know how great a load can be carried with the required acceleration, solve A or B for W and get

$$W = \frac{Pl}{70 (V_2^2 - V_1^2)} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (C)$$

If W, P, l and V_1 are known, and V_2 is desired, solve for V_2 and get

$$V_2 = \pm \sqrt{\frac{Pl}{70W} + V_1^2} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (D)$$

In determining l, since P can never be constant, nor even approximately constant, through any considerable change in speed, it is not uncommon to find l for a change in speed of 1 mile per hour, using successively V_1, $V_1 + 1$, $V_1 + 2$, etc., as initial speeds, until the required change is reached, when the sum of the several values of l will be the distance required. If $V_2 = V_1 + 1$, equation (B) becomes

$$l = 70 \frac{W}{P} (2V_1 + 1) \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (E)$$

The load W in any problem likely to arise would be known or assigned from some estimate made as hereinafter indicated. The tractive effort P must be estimated by subtracting from the estimated total tractive effort of the locomotive, the resistance due to such grade as the train may

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no simple locomotive in common use can ever exert its full tractive effort of adhesion, which is usually estimated to be as high one-fourth of the weight on the drivers for favorable conditions of track, and not usually lower than one-fifth under quite unfavorable conditions.

The Baldwin Locomotive Works states that the initial pressure in the cylinder may vary from full boiler pressure at very low speeds to 85 per cent of boiler pressure at high speeds of 300 revolutions per minute, and uses rather better than 90 per cent of the initial pressure when the speed is less than 50 revolutions per minute, indicating that the full tractive effort of adhesion may be realized by the cylinders at very slow speed.

Further road tests are perhaps necessary to establish the facts. The locomotive testing plants thus far devised, are not adapted to tests of high tractive effort at slow speed.

be on, and the ordinary train resistance, an unknown, and in nature an indeterminate quantity.

Many attempts have been made to determine a rational expression or formula for train resistance, but none has yet been devised, nor is it probable that any simple formula ever will be devised that shall correctly give the quantity known as train resistance. It depends on the condition of the journals and the weight on them, on the condition of the rail surface and the weight on it, on the pattern of the wheels, on the condition of the roadbed, on the temperature, on the velocity and direction of the wind, the speed of the train, etc. It is usually estimated at so many pounds per ton of train, and some of the estimates will be given. Grade resistance, being the action of gravity, on an incline may be determined with precision, and is always proportional to the weight of train.

Tractive effort.

The tractive effort of the locomotive has three limits; it cannot possibly be greater than the tractive effort of adhesion which is the weight on driving wheels multiplied by the coefficient of static friction between wheels and rails; nor can it be greater than the cylinder tractive effort which varies with the steam pressure in the cylinders, the diameter of the pistons, the stroke and the diameter of the driving wheels. If the cylinders are large enough, the drivers small enough, and the steam pressure high enough, the cylinder tractive effort would equal the tractive effort of adhesion, and the locomotive should be so designed that this is the case at low speeds. As the speed increases, the effective pressure in the cylinders falls, and the full tractive effort of adhesion cannot be had; moreover, with such boilers as have as yet been devised, the supply of steam af high pressure necessary to give the full tractive effort of adhesion cannot be maintained at high speed.

A boiler is capable of developing a more or less definite horse-power, and if the work performed is performed at high speed, the force exerted must be relatively small if the power exerted remains constant. Thus we have the boiler tractive effort as the limiting quantity at anything over the lower speeds of from 6 to 10 miles an hour, the precise limit depending on the design of the locomotive.

The coefficient of static friction between wheel and rail is usually estimated at about one-fourth for favourable conditions, as high as one-third with a sanded dry rail, and as low as one-fifth or less for ordinary winter conditions.

In determining P, therefore, for low speeds under 6 miles an hour, either the tractive effort of adhesion, *i. e.*,

$$T_a = \text{weight on drivers} \times \text{coefficient of friction}$$

or the cylinder tractive effort should be used, and for higher speeds, either the cylinder tractive effort or the boiler tractive effort. It is practically always true that boiler tractive effort must be used at speeds of over 8 to 10 miles an hour. In any event, the tractive effort that is smallest must be used.

Cylinder tractive effort is given by the formula

$$T_c = \frac{C^2 L p}{D} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (F)$$

in which C is the diameter of the piston in inches, L the stroke in inches, p the mean effective pressure in the cylinder in pounds, D the diameter of the drivers in inches, and T_c the tractive effort in pounds.

The boiler tractive effort is given by

$$T_b = \frac{375 \mathrm{IHP}}{S} - F \quad \text{. . . . .} \quad (G)$$

in which IHP is indicated horse-power, S is speed in miles per hour, F is the machine friction reduced to pounds of tractive effort, and T_b is the tractive effort in pounds. The first term of this formula, although not new, is not so generally known but that its derivation may be given.

One horse-power is 33,000 ft.-lb. of work per minute, or 60 × 33,000 ft.-lb. per hour. Assuming no losses from friction, the tractive effort multiplied by the distance through which it acts in a given time, equals the work done in that time, and this divided by the foot-pounds of work corresponding to one horse-power for the given time, should be the horse-power developed by the locomotive. Therefore

$$\frac{T_b \times S \times 5280}{60 \times 33000} = \mathrm{IHP}$$

or

$$T_b = \frac{375 \mathrm{IHP}}{S}$$

And since there are losses due to friction of the machine parts that friction must be deducted, giving equation (G).

The horse-power of a locomotive is not usually given, but if not known it may be estimated from the heating surface.

The maximum power per square foot of heating surface varies, with the design of the locomotive, but recent tests (¹) seem to indicate that simple freight locomotives developing full power produce one cylinder horse-power for each 2·3 square feet of heating surface, varying somewhat either side of this average, and that compound locomotives may produce one cylinder horse-power for each 2 feet of heating surface with very decided variation either side of this mean value. Thus, for a simple freight locomotive, the boiler tractive effort may be expressed by

$$T_b = \frac{375 \times \dfrac{H}{2 \cdot 3}}{S} - F = \frac{163 H}{S} - F$$

in which H is square feet of heating surface and F includes the rolling resistance of the drivers. F varies with the speed between limits of 6 and 25 per cent of the indicated power, but with the locomotive developing full power, or a little less, it may fairly be taken at 10 to 12 per cent for estimates. In round numbers, therefore, the boiler tractive effort is

$$T_b = \frac{145 H}{S} \quad \text{. . . . .} \quad (H)$$

(¹) Pennsylvania Railroad tests at the Louisiana Purchase Exposition, which seem to confirm earlier results of professor Goss.

Grade resistance.

Grade resistance, in pounds per ton of train, is given by

$$R_g = 20r.$$

in which r is the rate of rise in 100 feet, or the rate per cent of the grade. It is a resistance or retarding force to an ascending train and an accelerating force to a descending train.

Train resistance.

The work done in drawing the train behind the tender on a straight, level track, is the product of the quantity called train resistance through which the train is drawn. Train resistance is usually considered to include all resistance taxing the tractive effort of the drivers, except grade and curve resistances. It includes the rolling resistance of the driving wheels, which in later estimates, because of the character of locomotive testing plants, is included with the machine friction. Train resistance arises from 1° journal friction; 2° rolling friction or resistance; 3° resistance due to oscillation and concussion; 4° head, tail and side resistance of the atmosphere.

Journal friction is a maximum of 15 or 20 lbs. per net ton at a velocity of 0 + just after starting from rest; it is not nearly so much when slowing down from motion to 0 + or after a momentary stop. From this maximum it falls rapidly as the velocity increases to an unknown minimum possibly approximating 2 lbs. per ton. It is very much affected by temperature, and if a minimum of 2 lbs. is realized in summer temperature, it is very probable that the minimum may be 4 to 6 lbs. in winter weather. It varies very little with velocity if the speed is above 6 or 8 miles an hour. It depends very much on the character of the lubrication and the condition of the bearings.

Rolling resistance is unknown in amount and is usually classed with journal friction. It doubtless varies much with the condition of the track, and with the insistent weight, and is little affected by velocity changes. Rolling resistance and journal friction together are assumed at from 2 to 3 lbs. per net ton in modern expressions for train resistance.

Resistance due to oscillation and concussion is unknown in amount, is believed to be very small, and probably varies with the square of the velocity.

Atmospheric resistance has been most thoroughly investigated by professor Goss at the Purdue Laboratory. Much depends on the form of the cars and the make-up of the train. A freight train of box cars moving through still air seems to be resisted by a force given by the expression $A = (0{\cdot}13 + 0{\cdot}01\ C)\ V^2$, C being the number of cars in the train. For the engine and tender alone $A = 0{\cdot}11\ V^2$ and for the train alone $A = (0{\cdot}016 + 0{\cdot}01\ C)\ V^2$. For passenger trains the coefficient of C is to be doubled. At ordinary freight train speeds the whole quantity is small, but at high velocities the resistance is considerable, consuming from 10 to 20 per cent of the tractive force of the locomotive. The foregoing values are for motion through still air. A head wind of velocity equal to that of the train, would increase the resistance four times, a side wind would have an unknown effect which would be quite large.

Summarizing all we know of train resistance, it is probable that the whole may be represented by an equation of the form

$$R = \left(A + BV + \frac{C}{(V + K)^2} + DV^2\right) W + MV^2$$

in which R is the total resistance in pounds, A, B, C, D, K and M are coefficients, some of which may be zero, to be determined by experiment, W the weight of the train, and V is the velocity in miles per hour. W being expressed in tons, the parenthesis gives the resistance in pounds per ton of train, wich is the usual way of stating it.

The commoner formulæ for train resistance, are much simpler than that just given.

The Baldwin Locomotive Works formula is

$$R_T = 3 + \frac{V}{6}$$

in which R_T is resistance in pounds per ton of train and V is speed in miles per hour.

The *Engineering News* formula is

$$R_T = 2 + \frac{V}{4}.$$

These formulæ make no allowance for the fact that loaded trains have a less resistance per ton than empty trains, and they also probably include the machine friction of the locomotive. In using these formulæ in connection with the boiler tractive effort, the undiminished value of the tractive effort should be used, namely

$$T_b = \frac{163H}{S} \quad \text{or} \quad \frac{375IHP}{S}.$$

Formulæ that are perhaps better for freight train resistance are those devised by Mr. Sanford L. Cluett to fit the curves of the late Mr. A. M. Wellington ; they are

For empty trains . . . . $R_T = 5{\cdot}4 + 0{\cdot}01S^2 + \frac{70}{(S + 3)^2}$,

For loaded trains . . . . $R_T = 3{\cdot}8 + 0{\cdot}0076S^2 + \frac{16{\cdot}4}{(S + 1)^2}$.

The formulæ give results probably much too great for high speeds and possibly somewhat too high for all speeds. The following modifications are suggested, and while less simple than the *Engineering News* or Baldwin formulæ, they are believed to fairly well fit freight train resistance curves, not including machine friction, and are applicable for speeds of from 0 + to about 35 miles an hour.

Loaded train . . . . $R_T = 3{\cdot}5 + 0{\cdot}0055S^2 + \frac{16}{(S + 1)^2}$,

Empty train . . . . $R_T = 5{\cdot}0 + 0{\cdot}007S^2 + \frac{8}{(S + 1)^2}$.

Curve resistance.

Curve resistance is usually estimated at about $^1/_2$ pound per ton of train per degree of curve. That is, a 4 degree curve will offer a resistance of $^4/_2$ lb. for each ton of train on the curve.

Solution of problems.

Having stated the fundamental formulæ, it remains to indicate their use in solving the problems mentioned in the beginning of this paper.

In advance, one formula for train resistance is adopted and diagrammed or tabulated so that the resistance for any speed may be taken at once from the diagram or table. It will perhaps be best if several diagrams or tables are made for various percentages of loading on the train, the several curves for partial loading lying between the curves of loaded and empty trains.

Next, for the particular locomotive to be discussed, a diagram or table of tractive effort should be made, using the boiler tractive effort formula for all speeds above that for which the boiler tractive effort equals the cylinder tractive effort, using, say, 80 per cent of boiler pressure as mean effective pressure in the cylinder formula, except that for speeds below 5 miles an hour 85 per cent of boiler pressure may probably be safely used. Should the tractive effort of adhesion be less than the cylinder tractive effort that quantity should be used for the lower speeds.

Problem 1. — To find the load a given locomotive can haul on a given grade at a given constant velocity. The sum of the resistances must equal the tractive effort; therefore, the tractive effort at the assumed speed should be placed equal to the train resistance and grade resistance, indicated by the weight times the resistance in pounds per ton, and the weight obtained thus:

$$T = W(R_T + 20r)$$

$$W = \frac{T}{R_T + 20r}.$$

If r is the ruling grade of the road, T should be taken for the minimum allowable speed; which is placed by different experimenters at from 5 miles per hour to 10 miles per hour. It should be that speed which is just enough to make stalling from small accidents of firing, or track condition, unlikely. When this speed is used, the rating for the locomotive over the division is obtained.

Problem 2. — Assuming this load, let it be required to determine the distance on some grade less than the ruling grade in which, if the locomotive exerts its full power, the velocity may be increased by 1 mile per hour. Again, the net tractive effort must equal the sum of the resistances, including that due to acceleration. The P of equation (E) becomes $T - W(R_T + 20r)$. T and R_T should be values either for S_1 or $(S_1 + {}^1/_2)$ or $(S_1 + 1)$. It will be more nearly exact to consider T and R_T the tractive effort and resistance for $(S_1 + {}^1/_2)$. Then (E) becomes

$$l = 70\,\frac{W}{T - W(R_T + 20r)}\,(2S_1 + 1)$$

$$l = \frac{70\,(2S_1 + 1)}{\frac{T}{W} - R_T + 20r)} \qquad \text{(I)}$$

If it is desired to find the space required to increase the velocity from S_1 to S_2 miles per hour, equation (I) is solved with successive values of S and corresponding values of T and R_T until the value of S_2 is reached; the values of l thus found are added for the required result.

If it is desired to know what average speed may be made up such a grade of length L, equation (I) is solved with successive values of S and corresponding values of T and R until the sum of the several values of l equals the length L; then for an approximate result average the initial and final speeds. For a more exact result each S or each $(S + {}^1/_2)$ is multiplied by the corresponding l, the products summed, and the sum divided by L. The sum of the l's will probably not just equal L, but extreme precision is useless in such a problem, since the assumed conditions are rarely those obtaining; the whole train does not enter the grade at once, may never be on the grade, and does not leave it at once.

Both of these problems may be approximately solved by using for T and R_T their values for the mean velocity, known in the first and estimated in the second, and substituting the resulting P in equations (B) and (D).

PROBLEM 4. — The procedure is as in the last problem, omitting the averaging.

PROBLEM 5. — A locomotive and train approaches a grade steeper than the ruling grade for which it is loaded at a speed of S_1 miles an hour, and may leave it at a speed of S_2 (less than S_1) miles an hour. How long may the grade be?

P of equation (B) is now essentially a negative or retarding force, and the parenthesis $(V_2^2 - V_1^2)$ becomes for $V_2 = S_2 - 1$, $-(2S_1 - 1)$ therefore (E) becomes

$$l = 70 \frac{W}{P} (2S_1 - 1)$$

and as before P is the difference between T for speed, S_1 or $S_1 - {}^1/_2$, R_T for the same speed and R_g, or

$$\begin{aligned} l &= 70 \frac{W}{T - W(R_T + 20r)} (2S_1 - 1) \\ &= \frac{70(2S_1 - 1)}{\frac{T}{W} - (R_T + 20r)} \qquad \text{(K)} \end{aligned}$$

Solving with successive values of S to S_2 and corresponding values for T and R_T, and summing up the results, the possible length of grade is obtained. Again, an approximate solution may be had by substitution in (B), using for P a value obtained by taking T and R_T at their values for the mean velocity on the grade, thus:

$$\begin{aligned} l &= \frac{70W(S_2^2 - S_1^2)}{T - W(R_T + 20r)} \\ &= \frac{70(S_2^2 - S_1^2)}{\frac{T}{W} - (R_T + 20r)} \qquad \text{(L)} \end{aligned}$$

If both numerator and denominator of (K) and (L) be divided by 20, there results

$$l = \frac{3{\cdot}5(2S_1 - 1)}{\frac{1}{20}\left(\frac{T}{W} - R_T\right) - r} \qquad \text{(K')}$$

$$l = \frac{3{\cdot}5(S_2^2 - S_1^2)}{\frac{1}{20}\left(\frac{T}{W} - R_T\right) - r} \qquad \text{(L')}$$

But from the equations given under problem 1

$$T = W(R_T + 20r)$$

and

$$r = \frac{1}{20}\left(\frac{T}{W} - R_T\right)$$

is the grade on which with tractive effort T and train resistance R_T, the locomotive can just draw the train at the constant velocity corresponding to T and R_T, and this quantity is seen to be the first term of the denominator in both (K′) and (L′). If, therefore, r' be the grade on which the locomotive can just draw the weight W at the mean velocity of $(S_1 + {}^1/_2)$ or $\frac{S_1 + S_2}{2}$, then (K′) and (L′) become

$$l = \frac{3{\cdot}5\,(2S_1 - 1)}{r' - r} \quad \text{(M)}$$

$$= \frac{3{\cdot}5\,(S_2^2 - S_1^2)}{r' - r} \quad \text{(N)}$$

The quantity r' may be tabulated in advance for the given locomotive when the problem of determining l for any grade on the road will be a very simple matter. r' is known as the virtual grade.

Equation (I) may be similarly treated and will then become

$$l = \frac{3{\cdot}5\,(2S_1 + 1)}{-r} \quad \text{(P)}$$

Problem 6. — This problem is determined by successive solutions of the preceding problems. Assuming the locomotive loaded for minimum speed on the ruling grade of the division, the average speed that can be made on the several grades is determined, taking care that a maximum speed of, say, 30 miles an hour, is never exceeded, and introducing all probable stops, the average speed over the division is then readily determined. This will be in the nature of things an estimate and should be checked by trial on the road.

Problem 7. — Problem 7 is quite complex. The method of investigation may be stated somewhat as follows. Determine the load to be hauled on the ruling grade at the minimum speed; from the maximum tractive effort required, determine the weight on drivers, and from the allowable unit weight the number of drivers (note that the result is rational and practicable; determine a desirable average schedule time, and with this and some grade on the division assumed at average speed to require the full capacity of the locomotive, and the determined load, estimate the total resistance and the necessary power to overcome this at the assumed speed; with this assumed power, a profile of the division, and the determined load, find the speeds at which the various grades can be worked, compare the resulting average with that deemed desirable and modify the power as may be necessary; determine the heating surface, and approximate dimensions of boiler by comparison with existing locomotives or *de novo*; see that the results are practicable; state the requirements to be a locomotive with the determined weight on drivers and the determined cylinder horse-power, to be developed most economically at the determined average speed, to be capable of such a maximum speed, and with such a maximum cylinder tractive effort as has been determined, and leave the proportioning to the locomotive designer, checking the design in these particulars when it shall be submitted.

Problem 3. — The time required to gain the velocity v feet per second from rest, if gained in the distance l feet is

$$t = l \div \frac{v}{2}$$

with v expressed in miles per hour S, since

$$v = \frac{5,280}{3,600} S$$

$$t = \frac{15}{11} \frac{l}{S}$$

and if the speed is to be increased from S to S_2 miles per hour in the distance l feet, the time required is

$$t \text{ seconds} = \frac{15}{11} \frac{l}{S_1 + S_2} \quad \dots\dots\dots \quad (R)$$

Hence, having found the distance required for a given acceleration or retardation, substitute it for l in equation (R) and solve for the time.

PROCEEDINGS

OF THE

SEVENTH SESSION

WASHINGTON : MAY, 1905

5th SECTION. — LIGHT RAILWAYS.

[625 .61 (01]

QUESTION XVII.

INFLUENCE
OF
LIGHT RAILWAYS ON THE MAIN LINES

Influence which the construction of light railways may have on the traffic of the main lines.

Co-operation of the main lines in the construction and working of light railways.

Reporter :

All countries. — Mr. C. de Burlet, directeur général de la Société nationale belge des chemins de fer vicinaux, membre de la Commission permanente du Congrès.

QUESTION XVII.

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PRELIMINARY DOCUMENTS.

Report, by C. de Burlet. (See the *Bulletin* of February, 1905, 2nd part, p. 817.)

Vide also the separate issue (in red cover) No. 33.

SECTIONAL DISCUSSION

Meeting held on May 5, 1905 (morning).

MR. VON LEBER, PRESIDENT, IN THE CHAIR.

The President. (In French.) — I now propose that we proceed immediately to take up the discussion of question XVII. (*Agreed.*)

The reporter, Mr. de Burlet, is not here, but Mr. Lembourg represents him and will give us a summary of the report.

Mr. Lembourg, National Light Railway Company, Belgium. (In French.) — Mr. de Burlet has been prevented from attending this session of the Congress.

He has asked me to submit the summary of his report in his stead.

The inquiries which Mr. de Burlet has made have been exclusively from the officers of the larger railroads. The light railways were not addressed. This inquiry was, in fact, intended chiefly to compare the traffic of junction stations before and after the opening of the light railways. Consequently, the large railways were naturally the only ones able to furnish the required comparisons. It must, however, be recognized that the results of this inquiry are neither fully complete nor uniform. It could not be otherwise if one bears in mind the great diversity which exists in methods of operation of transfer stations, in systems of freight charges for mixed freight and in the manner at collecting statistics. Certain systems have, indeed, furnished comparative figures per unit of transportation (number of passengers, freight tonnage, etc.).

For other systems, the comparisons have been made on the basis on the cash receipts, sometimes separating the passenger and freight traffic, and sometimes lumping them together.

But most frequently, in these cases, the accounts of the large system indicate only the receipts at the transfer station for the outgoing traffic; the incoming traffic, that is, the traffic delivered by the main line to the light railway, is thus omitted in the comparison. Besides, this comparison of money receipts is not conclusive as to the question treated, especially when tariff reductions have come into force on the larger line after the opening of the lighter road, affecting the traffic of the latter.

Finally, on many light railways (Austro-Hungary, Russia, British India, etc.), the through traffic which is transported on the main road and on the light road, have one tariff directly from the starting point to the place of destination, without any special rebooking at the transfer station, and in this case, the comparison of the figures must become much more uncertain.

These various considerations enable us to appreciate the difficulties which Mr. de Burlet has encountered in coordinating the figures furnished to him. His report cannot, therefore, be considered as a precise mathematical document, and allowance must be made for unavoidable omissions and inaccuracies. As an illustration, I may point out that the very elaborate report presented by Mr. Ziffer on question XVIII, seems to indicate that there are no light railways in Russia. This information has been furnished to Mr. Ziffer by the Russian government itself (*see* page 65 of report No. 2 on question XVIII) (¹). But Mr. de Burlet has received information from the South-Western State Railroads of Russia and the Libau-Romny Railway, which appears in conflict with this statement. The latter roads have furnished detailed figures for the light railways connecting with their lines. These figures leave no doubt as to the existence of light railways in certain regions of the Russian empire and as to the favourable influence of these light railways on the traffic of the main system.

Disregarding this detail, the information and the figures furnished in Mr. de Burlet's report, appear to decide the principle of the question submitted to the Congress.

It should be first noted that the almost unanimous opinion of the great lines which have replied to the questions, affirms the beneficial effect exerted on their own traffic by the light railways connected with their system. A single French company — the Western — makes some exceptions as to certain light railways running more nearly parallel than at right angles to its own lines, and for this reason it considers them rather as competitors than as feeders. Chiefly because of fiscal considerations, the great lines in Italy have similarly been subjected, at certain points, to an active competition, especially in passenger traffic, by some steam tramways. This explains the reply received by Mr. de Burlet from the Company of the Railroads of the Mediterranean, but it seems that this reply is due to a confusion between those light railways which are really connections of the main system and suburban tramways, the main object of which is to bring the inhabitants of the adjacent country to the large centres. The question of this suburban traffic has already been discussed before the Congress, especially during the Paris meeting in 1900, where Messrs. Colson and de Burlet brought out the fact, that in certain cases, this traffic has been more a burden than an advantage to the great lines.

I think, therefore, that I need not insist on this point.

It would be a useless repetition to take up, system by system, the abstracted replies of Mr. de Burlet's report. Numerous figures will be found there to which I need merely refer the section. The most interesting of these figures, as far as the question discussed is concerned, are perhaps those furnished by the French Midi

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(¹) Vide *Bulletin of the Railway Congrss,* No. 12, December, 1904, p. 1827.

Company. This company has compared the receipts of a series of junction stations (before and after the starting of the light railways and also in 1902) with the cash receipts in the same years of other stations (comparison stations) having similar local traffic, but not being the junction point for a light railway. From this comparison, the company arrives at the conclusion that, on the average, the light railway system has increased the traffic of the main line at the junction points by about 49 per cent.

Similar comparisons leading to conclusions of the same character could be made from the information furnished by the comparison of stations for various lines in British India and in Russia (pages 23 and 33 of the report) (1).

This is, in short, the essential and crucial point of question XVII, and, it seems to me, that in this respect the inquiry made by Mr. de Burlet was decisive.

Besides this consideration of the increase of the traffic of the main line, the inquiry referred to the incidental advantages derived by it as follows :

1° Better utilization of rolling stock;
2° Simplification of accounts;
3° Reduction in cost of maintaining the freight equipment.

Replies were almost unanimously in the affirmative as regards the better utilization of rolling stock, but the two other advantages appeared more doubtful, or at all events of very slight importance.

As regards cooperation with trunk lines, either for the construction or operation of light railways, it appears to have been rather the exception everywhere up to the present time, excluding cases where the trunk line is operated by the State itself, which, however, is tending to become the general rule in continental Europe. Most frequently when the operation of the light railway is kept separate, this cooperation with the main line is confined to the granting of facilities for the establishment of transfer stations and the everyday details of the service of the latter.

The conclusions to be submitted to the general meeting might, I think, be drawn up about as follows :

" From the data furnished to this and previous sessions, it is obvious that light railways connected with main lines in most cases bring a considerable increase of traffic to the latter.

" It is therefore to the advantage of main lines to encourage the construction of such light railways and especially to give them all possible facilities for establishing junctions and for operating these conveniently and cheaply. "

The President. (In French.) — I declare the discussion now open.

The subject is of such high importance that we ought to deal with it seriously. I hope, therefore, that members who are experts on the subject will speak and expound to us the results of their own experience.

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(1) Vide *Bulletin of the Railway Congress,* No. 3, February, 1905 (2nd part), p. 837 and 847.

Mr. W. M. Acworth, *principal secretary*. — I thought some one had better start the discussion, so I will say just one word.

I cannot say anything of what has been done in England to help light railways, because practically nothing has been done, but I can say, of my own knowledge, that there are a good many cases in which light railways might have been made, and very probably would have been made, but the expense of joining the great company has been so large that it has checked the development.

Our English law is practically that if anybody makes a junction with an existing railway company, the newcomer has to pay the whole expense, and the whole expense in England, where very elaborate signalling arrangements are required, is extremely heavy, and it has acted as a great obstacle to light railway development.

Other gentlemen can probably speak of the experiences of other countries.

The President. (In French.) — Mr. Acworth has just told us that unfortunately in England the facilities usually accorded by main railways to light railways, are not provided, and that if light railways desire to construct their lines to connect with main lines, they have to bear the whole cost; in other words, the great companies do not share in the necessary expenditure.

In these circumstances, the cost is so high that usually no one can afford to build light railways.

My colleagues will doubtless be grieved to learn that the conditions are made so onerous for light railways. And yet it would be all to the interest of the great companies to facilitate the construction and growth of small lines and branches.

Accordingly, we should like to hear what members will be kind enough to tell us of what happens in their respective countries. I make a special appeal to our American friends. In America, there are vast lines and the distances are enormous. It is, therefore, opportune to consider light railways here, for they ought to be interspersed among the main lines with a view to developing traffic.

Mr. Scialoja, Sicilian Railways, Italy. (In French.) — I could have wished that some American delegates would have replied to our president's appeal, but since there are none here, I will give you a few explanations about the reply sent by the Mediterranean railway company.

Mr. de Burlet ignores this reply, because he took it for granted that this company concerned itself solely with suburban tramways.

There is a possibility of some misunderstanding here, for we speak of lines as tramways also that serve districts a good distance apart.

So tramways do not serve suburban districts only.

Mr. Lembourg, who is a Belgian, must be acquainted with Belgian companies that work hundreds of kilometres and that are not interested only in suburban tramways.

In Italy, the great railways regard the tramways as competitors and are not inclined to facilitate their being connected with the main lines, but this position of affairs will alter, because, from the 1st of July next, the railway organization will be modified radically. From that date, the main lines will be worked immediately by the State; there is now a bill before the Senate to regulate through services and junctions between the small lines and the main railways in quite a liberal manner.

Up till now, the main lines were worked by private companies which were defending their traffic against the inroads of the secondary lines. Henceforth the little lines will be encouraged.

The President. (In French.) — Mr. Scialoja, an Italian delegate, has reminded us that in his country there is no great difference between tramways and light railways. The tramway lines start from large towns and run far into the country. In these circumstances, these tramways in a way compete with the main lines, that is to say, with the ordinary railways. The result is that the railways which work the main lines are hardly inclined to encourage the growth of these lines of local interest. But this rivalry will soon cease, because the main lines are going to be operated by the State in Italy. The State being then at the head of a large system and not possessing strictly limited interests, as did the private companies, will encourage the development of small railways of local interest.

I take this opportunity of reminding the section that we shall encounter a difficulty in defining the different kinds of lines. There is no distinct difference between local railways and light railways.

In Austria, we regard as tramways, all railways that run on the same roadbeds as carriages and carts, but this distinction is not accepted everywhere.

I may, however, remark that, in a general way, the Railway Congress has nothing to do with tramways; such lines are outside our scope. If we had included them in our programme, this discussion would have proved much wider.

Consequently, gentlemen, I beg you to leave tramways out of our discussion. In this section, we have to concern ourselves with branches of main lines, that is to say, with light railways intended to bring traffic to main lines, and the conclusions of Mr. de Burlet's report seem to state that it is to the distinct financial advantage of main lines to encourage the development of little lines.

I believe Mr. Lembourg has prepared some new conclusions and I now ask him to be kind enough to read them out.

Mr. Lembourg. (In French.) — The following are the conclusions :

" It may be said in general that light railways are incontestably useful auxiliaries to the main line railways, and accordingly there is every reason that the main line railways should show themselves generous in granting all possible facilities. It is to be desired that all railway administrations should be inspired by the same liberal ideas as those in Austro-Hungary, and adopt conditions as broad and simple as possible to facilitate junctions and the operation of the exchange service with the light railways. "

The President. (In French.) — I am sorry that more delegates are not present, for the discussions of the 5th section are assuredly of as much importance as those engaging the attention of the other sections.

It is obvious that the light railways which bring traffic to main lines are of extreme importance, especially in countries where the distances are great.

In the country whose guests we are, this subject deserves quite special attention, but I fancy our American friends have not so far paid much attention to it.

Mr. W. M. Acworth, *principal secretary*. — I would suggest to the meeting, whether it is not desirable to put in something covering the point that Mr. Scialoja has made. I think it is quite clear that the tramways in Italy, and it certainly is quite clear that tramways in America, are very serious competitors with the main line railways; and I think it would be desirable to put in that this conclusion of the section refers to the case of light railways joining main line railways in country districts and not to the case of railways or tramways — whatever they are called — that start out of the towns alongside of the main line railways.

The President. (In French.) — What do you think of that, Mr. Scialoja?

Mr. Scialoja. (In French.) — I approve the remarks, Mr. President.

Mr. Lembourg. (In French.) — We might speak of light tributary lines and not of lines starting directly out of towns. As a matter of fact, lines indubitably tributary may end in towns.

Mr. L. Weissenbruch, Belgian State Railways. (In French.) — There is an essential difference between America, which is a new country, and the continental countries, that is to say old countries.

Here they put up manufacturing centres in a position where they are conveniently situated as regards their connections with main lines, whereas in old countries there are pre-existing centres, and it is found necessary to supply these with railway stations, it not being possible to leave them out. The difference is therefore considerable. And our President is right when he says that this subject is one of great importance.

Here every factory so to speak wants to be near a station, and the country being new, people take good care not to build a factory in a place where it will be badly situated as regards its connections with the main lines. That is an all-important point.

The President. (In French.)—What Mr. Weissenbruch has just said is quite true as a rule. A factory will be built where one chooses, provided one can get the necessary land cheap, but some industries cannot be dumped down where one chooses.

For instance, there are metallurgical industries or petroleum mines which are tied to the locality, so to speak, and must be established at an individual point. In that case, owners of works or mines of that kind would be glad to get light railways connected with main lines.

Mr. L. Weissenbruch. (In French.) — You are right, Sir, from the special standpoint you have taken up, but as in America traffic is carried long distances, before establishing works, an attempt is made to get a branch of some main line to the spot, the branch being built in some cheap manner. So far, no quite similar position has arisen in America as in the old countries, but it probably will arise, especially in the most densely populated Eastern States, and that too perhaps in no very distant future.

I hope Americans who are better informed on this subject than I am, will kindly enlighten me upon this point...

The President. (In French.) — Me too.

Mr. L. Weissenbruch. (In French.) — ... but I believe I may say that here the general tendency is for industries to occupy a larger sphere and to produce greater quantities at a time. But, when such large quantities are produced, one can select the locality better and at the same time build a town; in other words, one does what Mr. Westinghouse for instance has done.

The President. — Just so.

Mr. L. Weissenbruch. — The point is this. Are there not in the East some places where it is necessary to connect some industrial centres to railway stations, and are there not in the East some manufacturing centres which are not connected yet by light railways to large stations?

I hope I make myself clear.

The President. (In French.) — We must now deal with our conclusions.

Here is the resolution that we have altered slightly in conformity with Mr. Acworth's remarks concerning tramway lines starting from large towns of which Mr. Scialoja spoke, and which, starting from large towns, compete with main lines.

To avoid any difficulty, we therefore propose to say as follows :

" It may be said, in general, that light railways, when they are really tributary to main lines, are unquestionably useful auxiliaries to the latter; consequently, the friendly cooperation of the main lines and concessions by the latter of desirable facilities are fully justified, and it is to be desired that all railway managements should be inspired by the same liberal ideas as are held on this subject in Austro-Hungary and adopt as broad and simple conditions as possible to facilitate junctions and the operation of interchanging traffic with light railways. "

If you have no objection to offer, we will adopt these conclusions.

— These conclusions were adopted.

— The meeting rose at noon.

DISCUSSION AT THE GENERAL MEETING

Meeting held on May 11, 1905 (afternoon).

MR. STUYVESANT FISH, PRESIDENT, IN THE CHAIR.
GENERAL SECRETARY, MR. L. WEISSENBRUCH.
ASSOCIATE GENERAL SECRETARY, MR. W. F. ALLEN.

The President read the

Report of the 5th section.

(See the *Daily Journal of the session*, No. 3, p. 42.)

" Mr. LEMBOURG (*Belgian National Light Railway Company*) stated that Mr. DE BURLET, being unable to attend the present session, had authorized him to present in his name the abstract of his report.

" The inquiries which the reporter has made have been exclusively from the officers of the larger railroads. The light railways were not addressed. This inquiry was, in fact, intended chiefly to compare the traffic of junction stations before and after the opening of the light railways. Consequently, the large railways were naturally the only ones able to furnish the required comparisons. It must, however, be recognized that the results of this inquiry are neither fully complete nor uniform. It could not be otherwise if one bears in mind the great diversity which exists in methods of operation of transfer stations, in systems for freight charges for mixed freight and in the manner at collecting statistics. Certain systems have, indeed, furnished comparative figures per unit of transportation (number of passengers, freight tonnage, etc.).

" For other systems, the comparisons have been made on the basis of the cash receipts, sometimes separating the passenger and freight traffic, and sometimes lumping them together.

" But most frequently, in these cases, the accounts of the large system indicate only the receipts at the transfer station for the outgoing traffic; the incoming traffic, that is, the traffic delivered by the main line to the light railway, is thus omitted in the comparison. Besides, this comparison of money receipts is not conclusive as to the question treated, especially when tariff reductions have come in force on the larger line after the opening of the lighter road, affecting the traffic of the latter.

" Finally, on many light railways (Austro-Hungary, Russia, British India, etc.), the through traffic which is transported on the main road and on the light road, have one tariff directly from the starting point to the place of destination, without any special rebooking at the transfer station, and in this case, the comparison of the figures must become much more uncertain.

" These various considerations enable us to appreciate the difficulties which Mr. de Burlet has encountered in coordinating the figures furnished to him. His report cannot, therefore, be considered as a precise mathematical document and allowance must be made for unavoidable omissions and inaccuracies. As an illustration, the speaker quoted the fact that the very elaborate report presented by Mr. Ziffer on question XVIII, seems to indicate that there are no light railways in Russia. This information has been furnished to Mr. Ziffer by the Russian government itself (*see* page 65 of the report No. 2 relating to question XVIII) (1). But Mr. de Burlet has received information from the South-Western State Railroads of Russia and the Libau-Romny Railway, which appears to conflict with this statement. The latter roads have furnished detailed figures for the light railways connecting with their lines. These figures leave no doubt as to the existence of light railways in certain regions of the Russian empire and as to the favourable influence of these light railways on the traffic of the main system.

" Disregarding this detail, the information and the figures furnished in Mr. de Burlet's report, appear to decide the principle of the question submitted to the Congress.

" It should be first noted that the almost unanimous opinion of the great lines which have replied to the questions, affirms the beneficial effect exerted on their own traffic by the light railways connected with their system. A single French company — the Western — makes some exceptions as to certain light railways running more nearly parallel than at right angles to its own lines, and for this reason, it considers them rather as competitors than as feeders. Chiefly because of fiscal considerations, the great lines in Italy have similarly been subjected, at certain points, to an active competition, especially in passenger traffic, by some steam tramways. This explains the reply received by Mr. de Burlet from the Association of the Railroads of the Mediterranean, but it seems that this reply is due to a confusion between those light railways which are really connections of the main system and suburban tramways, the main object of which is to bring the inhabitants of the adjacent country to the large centres. The question of this suburban traffic has already been discussed before the Congress, especially during the Paris meeting, in 1900, where Messrs.

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(1) Vide *Bulletin of the Railway Congress*, No. 12, December, 1904, p. 1827.

Colson and de Burlet brought out the fact that in certain cases this traffic has been more a burden than an advantage to the great lines.

“ The speaker believed that he need not, therefore, insist on this point.

“ It would be a useless repetition to take up, system by system, the abstracted replies of Mr. de Burlet's report. Numerous figures will be found there to which the speaker merely referred the section. The most interesting of these figures, as far as the question discussed is concerned, are perhaps those furnished by the French Midi Company. This company has compared the receipts of a series of junction stations (before and after the starting of the light railways and also in 1902) with the cash receipts in the same years of other stations (comparison stations) having similar local traffic, but not being the junction point for a light railway. From this comparison, the company arrives at the conclusion that, on the average, the light railway system has increased the traffic of the main line at the junction points by about 49 per cent.

“ Similar comparisons leading to conclusions of the same character could be made from the information furnished by the comparison of stations for various lines in British India and in Russia (pages 23 and 33 of the report) (¹).

“ This was, in short, the essential and crucial point of question XVII, and, it appeared to the speaker, that in this respect the inquiry made by Mr. de Burlet was decisive.

“ Besides this consideration of the increase of the traffic of the main line, the inquiry referred to the incidental advantages derived by it as follows :

“ 1° Better utilization of rolling stock;

“ 2° Simplification of accounts ;

“ 3° Reduction in cost of maintaining freight equipment.

“ Replies were almost unanimously in the affirmative as regards the better utilization of rolling stock, but the two other advantages appeared more doubtful or at all events of very slight importance.

“ As regards cooperation with trunk lines, either for the construction or operation of light railways, it appears to have been rather the exception everywhere up to the present time, excluding cases where the trunk line is operated by the State itself, which, however, is tending to become the general rule in continental Europe. Most frequently when the operation of the light railway is kept separate, this cooperation with the main line is confined to the granting of facilities for the establishment of transfer stations and the everyday details of the service of the latter.

“ The conclusions to be submitted to the general meeting, according to the speaker, could be drawn up about as follows :

“ From the data furnished to this and previous sessions, it is obvious that light

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(¹) Vide *Bulletin of the Railway Congress*, No. 3, February, 1905 (2nd part), pp. 837 and 847.

railways connected with main lines in most cases bring a considerable increase of traffic to the latter.

" It is therefore to the advantage of main lines to encourage the construction of such light railways and especially to give them all possible facilities for establishing junctions and for operating these conveniently and cheaply. "

" Mr. W. M. Acworth (*British Government*) stated that unfortunately the facilities afforded to small companies by the great ones do not exist in England. When it is sought to establish light railways for the purpose of connecting with main lines, the light roads are compelled to defray all expenses involved; that is to say, the large companies will not share them in any way. Under these conditions, the expense is so heavy that, as a rule, light railways are never built.

" The President expressed the opinion that all present regretted like himself to hear such unfavourable statements as those just expressed by Mr. W. M. Acworth. If the section believed that Mr. de Burlet's conclusions were clear and correct, it would in every way be to the interest of the large companies to facilitate the construction of light railways. He, therefore, thought it would be very interesting if delegates would state the conditions in their several countries, particularly in America, where great lines exist, between which light railways should be laid to facilitate traffic.

" Mr. Scialoja (*Sicilian Railways*) stated that a bill has now been passed in Italy regulating in a very liberal manner connections between small and large lines. On July 1st next, the great national roads will pass into the hands of the government, and he hoped that, consequently, the government will assist in the construction of branch lines and secondary railways. At present, the main lines are in the hands of private companies.

" The President stated that tramways (street railways) are not included in the programme of the Congress, and that there is in Europe a special congress for railways of that character. There is a great difference between large lines and tramway lines. Tramways start from large cities and run some distance into the country. Under these conditions, these lines compete to some extent with regular railways. The consequence is, that large railway systems have no special inducement to favor the development of these tramways and railways of local interest, but this clash of interests will soon cease as the great railways are going to be operated by the State in Italy. The State, having no interests like those of private companies, will favour development of small lines of local interest.

" The section, he said, to consider branches from the main lines; that is to say, small lines intended to act as feeders for the large ones, and Mr. de Burlet's report tends to indicate that it is to the interest of the main lines to favour the development of light railways.

" Mr. L. Weissenbruch (*Belgian State Railways*) thought that the question was a different one in America, because when large factories are to be built in new countries, they are built only along the main lines.

" The PRESIDENT believed there are also industries in America where the factories cannot be located on main lines, as it would be desirable to do. There are industries, like oil, for instance, where the manufacturing plant must be located directly on the spot.

" Mr. L. WEISSENBRUCH replied that if traffic had to be carried very long distances, a branch was constructed to the main line to avoid transhipment.

" The following draft of conclusions was proposed by the section to the general meeting. "

The President. — The following are the

CONCLUSIONS.

" It may be said, in general, that light railways, when they are really tributary to
" main lines, are unquestionably useful auxiliaries to the latter; consequently, the
" friendly cooperation of the main lines and concessions by the latter of desirable
" facilities are fully justified, and it is to be desired that all railway managements
" should be inspired by the same liberal ideas as are held on this subject in Austro-
" Hungary and adopt as broad and simple conditions as possible to facilitate junc-
" tions and the operation of interchanging traffic with light railways. "

— The conclusions were adopted.

Mr. von Leber, *president of the 5th section.* (In French.). — I think I ought to say that it was not by my request that the section mentioned Austro-Hungary in the conclusions.

5th SECTION. — LIGHT RAILWAYS.

[625 .611]

QUESTION XVIII.

DIRECT FINANCIAL CO-OPERATION
BY THE STATE AND BY LOCALITIES INTERESTED
IN THE
DEVELOPMENT OF LIGHT RAILWAYS

Financial co-operation by the State (General Government) and by localities interested (counties, districts, parishes, etc.) in the development of light railways.

Results obtained in Belgium by the institution of a central authority for studying the projects supervising the construction and organizing the working of secondary railways, constructed with the financial assistance of the State and of the districts affected.

Reporters :

France, Belgium, England and Germany. — Mr. C. **Colson**, conseiller d'État, ingénieur en chef des ponts et chaussées de France, membre de la Commission permanente du Congrès.

Other countries. — Mr. E. A. **Ziffer**, ingénieur civil, président du chemin de fer de Lemberg-Czernowitz-Jassy (Autriche).

QUESTION XVIII.

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PRELIMINARY DOCUMENTS.

Report No. 1 (France, Belgium, England and Germany), by C. Colson. (See the *Bulletin* of October, 1904, p. 1151.)

Report No. 2 (other countries), by E. A. Ziffer. (See the *Bulletin* of December, 1904, p. 1809.)

Vide also the separate issues (in red cover) Nos. 11 and 19.

SECTIONAL DISCUSSION

Meeting held on May 8, 1905 (morning).

Mr. W. M. ACWORTH, PRINCIPAL SECRETARY, IN THE CHAIR.

The President. (In French.) — As Mr. von Leber has been kept at a meeting of the Permanent Commission, he has asked me to take his place temporarily.

I now beg to call upon Mr. Fontaneilles to summarize Mr. Colson's report.

Mr. Fontaneilles, Department of Public Works, France. (In French.) — The reporter, Mr. Colson, who has been prevented from attending the Washington Congress, asked me to take his place. I will try to summarize his report to the best of my ability. The following is the summary :

Mr. Colson stated that the need of financial aid for light railways is one of the characteristics of that class of railways, because the trunk systems of a country are capable of earning a revenue in proportion to the capital expended; the same is true of city lines in general. But rural lines which are intended to connect localities of small importance with great trunk lines, are seldom able to do so. It is, however, often for the public benefit to build such lines. Hence the necessity of subsidies

The difficulties encountered in establishing arrangements of this nature are due to two causes :

1° The subsidies have to be provided by different budgets. Generally, the initiative in the construction is taken by a province or a department or a district of a certain size. Frequently the communities concerned lend their aid; finally the aid of the State is also demanded;

2° It is also necessary to adjust the financial relation of the subsidizing authorities to the operating companies, for it is accepted even in the countries where the trunk lines are operated by the State, that operation by private companies is more suitable for light railways. But the problem is exceedingly delicate. In fact, the most simple system is that which consists in granting to the undertaking a fixed subsidy at the outset, whether it be in a lump sum or in yearly payments; but this system has the disadvantage of giving support which may be insufficient, or on the other hand, may be more than really required. The subsidizing authorities, therefore, ordinarily prefer methods which will insure to the undertaking the support which it really needs. They are thus led to organize a sort of partnership, the regulation of which consequently offers numerous difficulties.

One method consists in permitting the company to provide the capital and making the subsidy sufficient to insure the payment of interest on the capital (including the sinking fund) if the net earnings should not prove sufficient. This system is known as guarantee of interest. In this case, it is necessary to allow the company to retain a portion of the net earnings, without which it will never be able to get along without appealing for subsidies; it has, in that event, no interest in the results of the operation.

It may also be arranged that the authorities furnish the capital and that the company turn over to them the proceeds of each year, after deducting a portion allowed to them as an inducement for good management. This system may be described as a profit sharing lease. Mr. Colson would express these methods by mathematical formulæ, stating that these two systems (or an intermediate system as, for example, that by which the public authority supplies directly one part of the capital, and guarantees interest on the other part) contain the principle of all the combinations used.

He then proceeded to examine them more in detail.

To fix the amount of the construction capital, the subsidizing authority may adopt several methods :

It may, itself, carry on the work directly, in whole or in part. It then need not fix the amount of capital.

It may, also, adopt the plan of contracting for a lump sum for the whole line. For instance, it may say to the management, " This line is worth 5 million francs (£200,000). " But such contracts have certain difficulties because the contractor is interested in economizing as much as possible on the amount of the contract, and may sacrifice to this consideration the future interests of the traffic. He may endeavor to expend, say, not more than 3 or 4 million (£120,000 or £160,000). Then a contract by kilometre may be adopted ; that is, the amount per kilometre may be fixed, for instance, at 60,000 francs per kilometre (£3,860 per mile); but this kind of a contract also contains its difficulties, for the contractor may then try to make the line longer than necessary. We thus arrive at a contract with unit prices, so that the amount of work actually executed is paid for, and not the expenses incurred. That means, that the capital expended by the contractor is estimated on the basis of the quantity of each kind of work done : masonry, earth work, and the amount of steel used. In this way the capital is estimated, not according to the expenses really incurred, because the price paid by the contractor is unknown, but according to the quantity of work really performed by him. To induce the contractor to exercise economy, a maximum is generally fixed for the expenses, and a bonus is provided for economizing below this figure.

The cost of operation must also next be determined, in order to keep an account of the expenses of the contractor, if a minimum of receipts is guaranteed to him. The determination of the annual cost of operation, which the company is to receive is another very delicate question. The most simple way to determine these costs of operation is to fix a lump sum — for instance, to say to the contractor : " We will allow you 3,000 francs per kilometre (£193 per mile) yearly, for three trains daily in both directions "; this is the general practice in France. Mr. Colson believed that in Belgium five trains daily are agreed upon.

But this simple formula makes it to the interest of the contractor to avoid carrying traffic which simply increases his expenses without any return. But it frequently happens that an increase of traffic causes the company to incur expenses larger than the portion of the net receipts due to that increase, which, by the terms of the contract, is allotted to the lessee. So that a company would often have an interest in avoiding any increase in traffic at all, whenever it would entail an increase in expenses that would absorb any large fraction of the additional expenditure.

Accordingly, it has become common to divide up the expense to be allowed, so that a contractor gets a fixed sum and a portion of the gross receipts. This leads to a formula with two terms, $a + b\mathrm{R}$, where a represents the fixed portion, R the gross receipts and b the coefficient. For instance, 1,000 francs $+ {}^{1}/_{2}$ R.

The company has then an interest to increase the gross receipts, because it gets a fixed sum of a 1,000 francs per kilometre (£64.7*s*. 5*d*. per mile) and a portion of the gross receipts which is equal, in the suggested instance, to one-half.

Whatever value be placed upon the coefficient, it is always too high for merchandise of high value and light weight, and too low for heavy freight, because the cost of transportation of these materials is often far higher than half of the receipts, and the company has, therefore, no interest to develop this kind — and this is the most interesting kind — of traffic. Herein lies the great defect of the formula with two terms.

It has thus been found necessary to add to the preceding formula a third term proportionate to the mileage of trains run, T, which gives the formula :

$$a + b\mathrm{R} + c\mathrm{T}.$$

The coefficient c represents a fraction of the mileage cost of the extra train, 45 or 50 centimes (7*d*. or 8*d*. per mile) for instance, so that this term added to the fraction $b\mathrm{R}$ of the earnings going to the lessee, reimburses him his expenses, even though the train conveys only a few passengers or only heavy goods carried at very low rates. The lessee can be still further encouraged to attract these goods, by adding a fourth term proportionate to the whole ton-mileage, $d\mathrm{K}$, in which K stands for the number of tons carried 1 kilometre (0·62 mile) and d a coefficient of 1 centime (0.096*d*.), for instance.

This formula makes it possible to lead the company in the direction in which the subsidizing authorities desire it to go. In some cases, however, further terms have been added proportionate to various elements, such as the actual number of tons or passengers carried, the distance run by trains or cars of each class. This is, then, in fact, a schedule of rates which replaces a lump sum contract. A formula with five, six or seven terms instead of three, is thus arrived at. These formulæ appear to be somewhat complicated, and Mr. Colson thinks a formula of three terms, if well considered in advance, suffices to insure the operation and to make it to the interest of the company to operate the road, in accordance with the public interest by attracting all the traffic that can bear a rate which will cover the cost, that is to ensure sound operation. It also happens sometimes that instead of guaranteeing to the leasing company its costs of operation on the results of a contract formula with several terms, the actual expenses of operation have been given to the company and a bonus fixed for economy. In this case, the lessor is under obligations to verify the expenses of the company. This is difficult and does not obviate the necessity for using a formula, for there must always be one so as to define a maximum expenditure that will be accepted. The difficulty in applying these formulæ consists in accurately foreseeing the consequences and in providing against the result that some unforeseen conditions may arise which would induce the company to operate the line in a manner contrary to the public interests. In France, they have now, after a tentative period, arrived at formulæ which seemed fairly to promise satisfaction to the different interests involved.

After these general remarks, the report of Mr. Colson contains an abstract and a history of legislation regarding light railways in France, Belgium, Germany, Ireland and Great Britain.

France. — In France, the first law relating to light railways dates from July 12, 1865. This law authorizes departments to establish these roads, allotting to them, according to their wealth, subsidies of one-quarter, one-third or one-half of the sum, which the department and the other interested parties furnished. This law has been replaced by that of June 11, 1880, chiefly because it had the defect of providing subsidies for construction only and not securing subsequent operation. About that time, 1880, nearly 3,600 kilometres (2,240 miles) of light railways were consolidated with the large systems, and there remained only as light railways, constituted as such by the law of 1865, about 1,000 kilometres (620 miles), more than four-fifths of which were of normal gauge. The average cost of construction was 140,000 francs per kilometre (£9,000 per mile). These railroads were consequently not strictly speaking very cheap. Average gross receipts in 1903, about 10,000 francs (£640 per mile); net income, about 2,400 francs (£154 per mile).

The law of June 11, 1880, substituted yearly payments for lump sum subsidies. It applies to light railways and also to tramways, but the word " tramway ", as used here, refers to light railways laid on public roads, and not to tramways in town or suburbs, for which the State never grants subsidies, provided they do not carry on an ordinary goods service. We are now speaking solely of real railways which connect different districts, the only ones that get subsidies from the State and from departments.

These railways obtain their concession from the departments, or in cases where they do not go outside the limits of a single commune, from the commune. This latter, however, occurs very seldom. In such cases, the State grants the concession (especially where the railway is laid on a national road) to the department, and the department, in its turn, assigns the concession to the company. It requires, however, that this concession be approved by decree, which always steps in (sometimes for important undertakings a law) to authorize the work, and to fix the amount of subsidies by the State. The schedules for maximum rates for the companies, are drawn up by the departments, but submitted to the approval of the ministers of public works, of the interior and of finance before the decree is issued. The law of 1880 provides that a subsidy of the State shall not exceed the subvention of the department and the communes. It also fixes a certain number of other maxima which are given in detail in Mr. Colson's report.

The results of the law of 1880 have been quite satisfactory. At the end of the year 1903, there were in operation in France 9,000 kilometres (5,600 miles) of light railways (one part of them being called tramways) in addition to 1,000 kilometres (620 miles), built under the law of 1865. There are, in addition, 3,300 kilometres (2,050 miles), either under construction, or for which concessions have been granted. This represents a total of more than 12,000 kilometres (7,460 miles) of light railways. The gauge of track generally adopted is 1 metre (3 ft. 3 $^3/_8$ in.). The cost of construction of the 9,000 kilometres (5,600 miles) under the law of 1880 was 60,000 francs per kilometre (£3,860 per mile). The gross receipts in 1903 were 3,700 francs per kilometre (£238 per mile) and the net receipts about 700 francs per kilometre (£45 per mile). These roads are therefore really light railways. The number of companies which have received concessions are about a hundred, but a large number of them either belong to, or are more or less dependent on, larger companies which have made a specialty of constructing and operating secondary railroads. The earlier concessions guaranteed the company against deficits in operation, and 5 per cent on the construction capital. At present, there is no guarantee against deficits in operation, and the guarantee on the capital is 4 per cent only. Frequently the departments themselves carry out some portion of the work with advantage, for they can utilize their engineering staff and can borrow on better terms than the companies.

Belgium. — In Belgium, the construction of light railways is secured by a special organization, the National Light Railway Company, created by the laws of the 28th of May, 1884, and the 24th of June, 1885. It is a public undertaking in which are represented the State, the provinces and the communes interested. This company is privileged, for no one can obtain a concession unless the national company has refused it. It has thus the preference for all concessions. The concession is granted by royal decree. Private persons are allowed to subscribe for shares, but in general the State subscribes a large part, often one-half, and the provinces and the communes almost the whole of the rest. The society has a capital in shares and keeps separate accounts for each line.

The State, the province and the communes are allowed, instead of paying in capital in the form of shares, to make annual payments for ninety years, which guarantee the bonds issued by the society. The administration is entrusted to a council of five members. The king names three, one of whom is chairman, and the shareholders nominate the other two. There is also a supervisory council of nine members elected by the shareholders, one for each province of the kingdom.

The society constructs the lines and then leases their operations to a contractor. Sometimes the lease is auctioned, sometimes settled by contract on private agreement. The amount of the rent to be paid is fixed by one of two formulæ, either by

$$a + b\mathrm{R} \text{ or } b\mathrm{R}.$$

This organization has produced excellent results. At the end of 1903, the company had obtained concessions for 3,076 kilometres (1,911 miles), 2,323 kilometres (1,443 miles) of which are already in operation.

The normal gauge is generally 1 metre (3 ft. 3 $^3/_8$ in.). The capital is on the average 53,000 francs per kilometre (£3,400 per mile). The gross receipts are 5,000 francs per kilometre (£320 per mile) and the net 1,900 francs (£122 per mile).

Germany. — In Germany, the federal legislation of the empire only intereferes as far as supervision is concerned and has nothing to do with the question of subsidies. It distinguishes : main lines, branch lines, narrow gauge lines.

The narrow gauge lines and a portion of the branch lines may be considered as light railways, and the legislation of the different States of the German empire has dealt with these lines in different ways. For example, the Bavarian State Railway system, containing 1,600 kilometres (1,000 miles) of light railways, which are called local or vicinal, are of normal gauge. For these, the persons interested were required to furnish some portion of the capital. In other cases, on the contrary, concessionary companies of small lines were subsidized. Only in Prussia, small railways, as they are there called, have acquired considerable importance under a law of a special organization. The small railways of Prussia are under the law of July 28, 1892. They are divided into town tramways and secondary railways, the latter being the only ones which interest us. The latter railways have extended to 6,400 kilometres, or about 4,000 miles. Their construction must be sanctioned by the presidents of provinces. The concessions for them are given sometimes to companies, sometimes to districts and sometimes to communes. In the beginning, it was intended to leave the task of subsidizing them to the provinces, the districts or the communes, but the government has been compelled to subsidize also. On general principles, its help equals that of the provinces or districts, sometimes more. The subsidy is furnished as capital, but the State participates in the profits of operation, either as a shareholder or as a bondholder. Concessions formerly were given to companies, but there is a tendency at present to give them to districts which frequently build themselves. The bulk of the lines are leased to companies who operate them for a consideration, retaining a certain portion of the net receipts. The average cost of construction was as high as 65,000 francs per kilometre (£4,200 per mile). The gross receipts were 4,800 francs (£310 per mile), the net 1,400 francs (£90 per mile).

UNITED KINGDOM. — Subsidies for light railways were the subject of special laws in Ireland in 1883 and in Great Britain in 1896. Mr. Colson indicates in his report that the situation has been described at previous congresses by Messrs. de Burlet, Acworth and Tatlow (1) and that he has very little to add.

Ireland. — In Ireland a law was in existence in 1883, which is known as the Tramways and Public Companies' Act, providing for a guarantee of interest at the rate of 4 or 5 per cent, which is to be voted by the grand jury (local county authorities). The government contributes to the guarantee of the authorities up to the extent of 2 per cent on the capital, but takes no responsibility for deficits in the receipts not covering the work of operating expenses. Under this plan, 475 kilometres, or 295 miles, of railways were built, generally of 3 feet gauge, and laid on highways ; these cost 73,000 francs on the average per kilometre (£4,700 per mile), and have 4,000 francs (£257 per mile) gross receipts. The cost of operation exceeds in some cases this amount.

In 1889, there was a second Light Railways Act in Ireland which replaced the guarantee of interest by a subsidy in capital. Under this law, there were constructed 310 miles, or 500 kilometres, of railways of broad gauge, similar to the main lines with which these connect. The average cost per kilometre is 93,000 francs (£6,000 per mile). No economical enough method appears to have been found up to the present time, for developing this secondary system.

Great Britain. — The rapid development of main lines has prevented the English people from taking much trouble to facilitate the construction of secondary lines until the date of the light railway act in 1896. This act was intended to reduce very considerably the formalities which made the building of railroads so difficult. Permission to construct the line can be granted by the Board of Trade instead of by parliament. The procedure is simplified especially as far as compulsory purchase is concerned.

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(1) Vide the *Bulletin du Congrès des chemins de fer*, No. 10, October, 1894, p. 799, No. 4, April, 1895, p. 954, the *Bulletin of the Railway Congress*, No. 1, January, 1900, p. 77, the *Proceedings of the 5th session* (London, 1895), vol. III, p. XVIII-3 and XVIII-88, and the *Proceedings of the 6th session* (Paris, 1900), vol. VI, p. XXXVIII-3 and XXXVIII-89.

As to subsidies, the law authorizes county councils, districts and cities to borrow money to subsidize light railways. It authorizes the treasury to make advances to them. Finally, in certain cases, to give subsidies up to one-half of the construction capital. Under this plan, besides some suburban tramways, there have been constructed some real light railways for agricultural districts, the only ones which interest us. Many projects have been under consideration, but all have not been carried out; the necessary capital is difficult to obtain for a great number of these enterprises for several reasons, especially because of their high cost, which is estimated to be on the average of 91,000 francs per kilometre (£5,860 per mile). It is possible that they would prove not sufficiently economical to develop easily.

Mr. Colson's report ends here; it contains no conclusions strictly speaking; it is more a general summary of the resolutions so far adopted. It is no easy matter to make fixed rules on such a subject. The problem for solution lies in discovering how to build and work railways under difficult and very variable circumstances. The proper solution to adopt varies therefore in each individual instance.

Nevertheless Mr. Colson's report is interesting because it shows the danger that may arise, from a financial standpoint, from the formulæ that may be used in guaranteeing interest or granting a subsidy to the concessionnaire.

The formulæ that seem the simplest often possess serious disadvantages because they usually mean that the interests of the concessionnaire will be opposed to those of the public, and this is the essential point to avoid.

It is especially, from this standpoint, that we ought to consider the subject of local railways, provided we wish to adhere to generalities, because, I repeat, in each individual case, there are special conditions that cannot be defined and discussed in a general report.

The President. (In French.) — I shall certainly be acting as the mouth-piece of all members of this section in expressing our most hearty thanks to Mr. Fontaneilles for his excellent summary of Mr. Colson's report.

Mr. Fontaneilles. (In French.) — On the subject of light railways, it is very difficult to formulate conclusions.

Moreover, Mr. Colson's report closes with a summary and not with conclusions.

The President. (In French.) — But we must draft some conclusion for submission to the general meeting. We might say, for instance, that there are several ways of attaining the same object.

Mr. Fontaneilles. (In French.) — We might suggest the following principle : " It is a good thing, in such cases, to give up broad gauge and adopt cheaper methods. "

In countries where light railways have developed much, metre (3 ft. 3 $^3/_8$ in.)

gauge has usually been adopted and methods of operation are extremely simple

Where people have chosen to adhere to standard gauge, they have not succeeded in getting many secondary railways built.

As regards leasing, another acceptable understanding is the following :

" Close attention should be paid to the consequences of different working formulæ, to avoid the risk of opposition arising between the interests of the concessionnaire and those of the public. "

These dangers only become evident as a rule after very useful study, and as a matter of fact the early formulæ, established on *a priori* considerations, soon proved faulty.

In considering this subject, these are the two rules that must not be neglected.

As for matters of detail, these depend above all upon surroundings, because the operation must be arranged in conformity with the varying demands of the district to be served, and also because it is necessary to consider the financial resources at command.

A member. (In French.) — Is it not advisable to concern ourselves with the financial cooperation of the great railway companies?

Mr. Fontaneilles. (In French.) — I may observe that our business is to consider the financial assistance of public authorities. The subject of financial cooperation of great railways was dealt with when we were considering question XVII.

The President. (In French.) — Yes, but I think we might here consider the principle of subsidies both from the State and from other public authorities.

The two points Mr. Fontaneilles has made, are first, that as much economy as possible ought to be put into the methods of operation. The other point he raises is that of the importance of arriving at the proper formula, so as not only to make a fair division between the company and the subsidizing authority. but also to encourage the company to develop the traffic, and not to starve it, lest it should pay, as in the early French days it paid the company, better not to carry traffic than to carry it at the price they got for it.

Mr. Veilhan, French light railways. (In French.) — I wonder whether there does not come within our scope the possibly extraneous, but none the less interesting, question of the financial assistance that may be rendered to secondary or light railway companies not by the State, but by the great railway companies. I may refer to what is happening in France where we have made several interesting experiments in this direction.

When the traffic is light, it is to the advantage of the great companies to hand over certain lines to secondary companies which they help financially.

Under an agreement entered into between the secondary and great companies, the former work certain lines under circumstances more favourable both to the great companies and to the secondary companies; it is therefore to the interest of both.

I will quote you an instance in Brittany where the Western of France has detached from its system a fraction of some 400 or 500 kilometres (250 or 300 miles) and handed it over to a secondary company. In conformity with an agreement entered into between them, the great company financially assisted the secondary company, which, being itself possessed of some credit, likewise assisted the great company. So there was a community of interests and it thus became possible, if I may so express myself, to operate a section of main line exactly as though it were really a light line. Hence the working expenses were lower, and this benefited the great company.

I should like to hear from American delegates whether they have tried the same thing in America, and whether there are any lines here existing under similar conditions.

The President. (In French.) — So far as I am aware, there is no classification of lines here; all railways belong to one category.

Mr. Fontaneilles. (In French.) — Nobody in America concerns himself much with matters relating to railways of local interest; it is a country in which railway systems grow unrestrictedly and rapidly, and so far the traffic has proved sufficient to cover expenses.

The President. (In French.) — In practice, there are light lines and main lines, but from a legislative standpoint there is no distinction in America. Similarly in England, until 1896, there was no distinction in this respect.

Mr. Fontaneilles. (In French.) — America is still able to build great railways. In France, hardly a single railway can be built that would pay a fair interest on the capital expenditure; consequently, to meet the demands of agricultural communities, we have to build lines that can only live with the assistance of subsidies.

The President. (In French.) — As I stated a few minutes ago, the position is similar in England.

I have before me a list prepared by the Board of Trade. There are about 80 kilometres (50 miles) of line belonging to six companies which have been removed from the category of ordinary railways and put under the regulations applying to light railways.

What has happened in the United Kingdom has occurred also with you, in Brittany.

Mr. Veilhan. (In French.) — Some railways in England originally passed as main lines have been converted in accordance with a later law, into railways of another class to which a cheaper regime could be applied.

But my remark had quite a different bearing. It would be interesting to see the system develop that I am recommending and that has already been applied in France, namely a great company that had got its concession under a law that obliges it to fulfil certain duties and undertake certain heavy expenses, detach from its system the less remunerative lines and have them operated by small companies, under different regulations and with a different regime.

The selines would be leased to secondary companies which would, in a sort of way, intersperse themselves between the main lines under an agreement whose clauses would have to be settled jointly. I do not know whether I make myself clearly understood.

To sum up, the great company would lend its assistance to a leasing company which would work part of the main line's system.

The President. (In French.) — Is there any difference between the case where a great company operates partly like a main line and partly like a light line, and where a great company operates the main line directly and hands over the concession of a little line?

Mr. Veilhan. (In French.) — There is a great difference.

In France, the main company must get a bill passed to allow it to detach from its system part of its lines and get them operated by a secondary company.

As soon as the authority is granted, the little company can operate more cheaply, because then the position is really similar to that of a secondary line.

The secondary company can make an advantageous arrangement with the principal company, and as its expenses are lower, it decreases by this very fact the expenditure of the great company. It must do so. Under these circumstances, I repeat, there is a gain both to the great and to the little company.

The President. (In French.) — Why, if the great company was working in accordance with the regulations that apply to railways of local interest, could it not operate the line as cheaply as a secondary company?

Mr. Veilhan. (In French.) — That question has been asked several times.

In France, the great companies have working arrangements that they cannot alter; for instance, they pay their drivers a fixed rate; this is a settled custom; no driver will ever take a wage below a fixed amount, just because he belongs to a great company. But a small company can get men at cheaper rates.

Mr. Fontaneilles. (In French.) — The great companies must have rather complicated regulations which cannot possibly be altered to provide for individual cases that may arise. These regulations are naturally devised for the great lines whose operation is most expensive. The result is that when they have to operate little lines, they spend more than the business warrants.

Mr. Lembourg, Light Railway Company, Belgium. (In French.) — As regards the public interest, what difference is there between operation by the great or by the little company?

Mr. Veilhan. (In French.) — The little company provides a little less comfort and a lower speed.

Our average speed amounts to 28 or 30 kilometres (17·4 or 18·6 miles) at the best. The great company maintains 30 to 35 kilometres (18·6 to 21·7 miles).

In addition, the secondary company provides slightly less facility at stations for forwarding luggage.

Perhaps too it has fewer employees and consequently the public finds fewer people to help in handling baggage.

It is not uncommon for a company to operate, for instance, at 2 francs or 2·50 francs per train-kilometre (2*s*. 6·90*d*. or 3*s*. 2·62*d*. per train-mile). The latest figure for 1904 amounts to 90 centimes (1*s*. 1·90*d*. per train-mile). The difference is enormous.

Mr. Lembourg. (In French.) — A distinction must be made. The first figures are averages applying to important trains such as those between Paris and Nice, for instance, whereas the other figures refer to little lines.

Mr. Fontaneilles. (In French.) — If they granted similar facilities to the public, it would cost the great company a much higher percentage to operate the line than a little company, because the wages paid to station-masters and drivers are much higher. A great company cannot have scales of wages. It must employ first class drivers, owing to the difficulty of driving important trains.

Mr. Lembourg. (In French.) — There are several classes of drivers everywhere.

Mr. Fontaneilles. (In French.) — A man who drives a train on a little line must be able to drive one on the main line.

Moreover, the old locomotives of main lines, which however are very heavy, are run on the little lines.

In France, there cannot be two categories of men. We practically cannot settle individual regulations and organize a special management for one portion of the system; the regulations are arranged for the whole system. The result would be that it would cost far more to operate.

Once again I say that I do not believe we can possibly deduce from all this any general conclusion. I think the conclusion should be that when little lines are not worth working on a liberal scale it would perhaps be better not to grant their concession to great companies.

It would be well to adopt this precautionary measure in view of the new situations that might arise.

Mr. Veilhan. (In French.) — Perhaps.

Mr. Fontaneilles. (In French.) — The remedy suggested by Mr. Veilhan would seem to me worthy of being recommended.

Mr. Veilhan. (In French.) — I mentioned a state of affairs that has arisen in France and it has enabled us to obviate certain difficulties. It would therefore be well to allude to it.

Mr. Fontaneilles. (In French.) — In countries where there has been no special legislation for light railways, lines of small importance which would have been better left as small railway systems have been absorbed by great systems. When great companies have to operate these lines, it may be that instead of implanting their methods of operation, it would be to their interest to turn them over to another company with a different method of operation which would consequently be able to effect economies.

However that may be, the question is one much more of instituting a remedy for an unsatisfactory state of affairs than of adopting a rule for the future.

Mr. Veilhan. (In French.) — That is what I mean. It would be well to suggest this remedy to the great companies, in view of the difficult eventualities that may arise.

Mr. Fontaneilles. (In French.) — Sometimes the great systems have their interest guaranteed. This is the case in France. Then it might be to the interest of the State to stimulate the great companies to detach from their system a batch of unremunerative lines and lease them. The guarantee of interest might in these circumstances be decreased, and that would be an advantage for the State.

The President. (In French.) — I now call upon Mr. Lembourg to summarize Mr. Ziffer's report.

Mr. Lembourg. (In French.) — I regret that I am taken unawares. My summary will doubtless give sad evidence of this fact.

Mr. Ziffer in his report reviews the countries not mentioned in Mr. Colson's report. In some of these countries, there has been no legislation; in Bulgaria, the Congo State and Spain, where bills have been introduced but have not become laws. In the United States, it may be said that what are called in Europe light railways do not exist. In Portugal also, there are no legal provisions on the subject, nor are there any in Russia or Uruguay.

In Turkey, however, the railways may all be regarded as light railways and a minimum amount of gross receipts is usually guaranteed by the State.

In the Argentine Republic, the government goes only so far as to grant free occupancy of the necessary land.

In Austria, it is at times the kingdoms or provinces of which the monarchy is made up that get the concessions, and then build and work the lines. The State subsidies assume various forms. Sometimes a profit is guaranteed or shares of the stock are taken — which is remarkable, because in other countries the government usually takes bonds. Usually also, the lines are taken over for State operation at a price very favourable to the small lines. Sometimes the State undertakes the construction for the account of local railways, employing the most economical methods possible. When the State guarantees the capital of a light railway, it usually builds and works the road itself. When a local authority guarantees, the line is generally built by the district in question and operated by the State. In Lower Austria the local authority not only builds, but also operates the railways.

In the case of Bohemia, 34 local lines have been built, with a total length of 1,122·7 kilometres (697·6 miles), and a capital outlay of 137,215,468 francs (£5,488,618.14*s.*). The kingdom has contributed in the form of loans and preferred stock 73 per cent; the State, in the form of subscription to capital stock, 7 per cent, and other interests 20 per cent.

Mr. Ziffer spoke in his report of the traffic of the Bukowina Local Railway, 82 per cent of which consists in transporting timber of various kinds, 6 per cent building materials and 5 per cent wheat and flour. Of the gross receipts, 14 per cent comes from passenger traffic and 86 per cent from freight.

In Hungary, the financial assistance from the authorities usually consists in subscribing up to 15 per cent of the common stock; 65 per cent must be contributed by the company as preferred stock.

As a rule, the lines are operated by the management of the State Railways, on the basis of refunding actual expenses.

In Denmark, the State has assisted by guaranteeing 4 per cent on the capital invested, including the cost of purchasing the land. But, in certain cases, the purchase of the latter is left to the parties interested to prevent an excessive appraisal of the land. Since the law of 1894, the State contributes one-half or three-quarters of the expense.

In Egypt, the free use of the land is granted and the government also allows a net sum of 900 francs per kilometre (£58 per mile), but this guarantee is of no practical value, because of its very trifling amount.

In Italy, the system of subsidies also prevails. This system has been modified by different laws. At first, the subsidy did not exceed 1,000 francs per kilometre (£64 per mile), by the law of 1873, but the law of 1881 raised the amount of the subsidy to 3,000 francs per annum per kilometre (£190 per mile), and even later to 8,000 francs (£510 per mile). It is now 6,000 francs (£380 per mile).

In Norway, there has been no general legislation on this subject. Special subsidies are stipulated for each line. Very often the State agrees to assume one-half of the cost of construction. One-half of this portion takes the form of a subsidy, the other half being represented by shares or stock.

In the Netherlands, the financial assistance of the State and provinces is not defined by any general law. Each separate concession is dealt with separately. In the Dutch Indies, the intervention of the authorities is confined to allowing the free use of the roads. The same is the case in Roumania.

In Servia, there is also a law which, up to this time, has had no application.

The principle of the law is that materials intended for the construction of light railways are exempt from duty.

In Switzerland, there is no general law specifying that subsidies be granted, but some cantons have given aid in the form of subscribing for shares. Under this category comes the Rhetic Railway, which has just gone into operation; the Confederation has subsidized it by subscribing for deferred shares; the Grisons canton has subscribed for ordinary shares and has besides guaranteed the interest on the debentures issued.

The President. (In French.) — I think we might make a conclusion out of the last part of Mr. Ziffer's report and one that the section might adopt.

Mr. Lembourg. (In French.) — Here is the conclusion to which our president refers :

The interest which the State, the provinces and the communes nearly everywhere take in light railways, is an undeniable proof of the high importance and great influence of these secondary or minor lines, as regards the improvement of the economic conditions of the countries, as well as from the point of view of civilization; for the building of railways makes it possible for countries, which till then have more or less remained apart, to join in the general progress, provided that the railways are built and organized to suit the local conditions.

Unfortunately, however, it is thought necessary to hold to the old systems of construction and working used on the main line railways; the result is that the financial results are very moderate, and that neither private capital nor private enterprise finds itself sufficiently encouraged to go in for undertakings which are so little remunerative.

Therefore it behoves all those who are interested in the construction and development of light railways, and in the first place for the State, which profits most by such lines, owing to the increased revenue which results from the creation of new industries, and to the increased business activity, to give sufficient financial assistance to ensure the construction of such means of transport, which form a long felt *desideratum*. Moreover, it is necessary to grant all possible facilities and simplifications in the building and working of these lines, so as to make it possible to carry out the work of coustruction and to purchase the rolling stock as cheaply as possible, and to give a modern and suitable organization to the different departments of the service; in short, to have simple, economical, commercial, rational working, which gives all facilities possible in matters of rating. In this way, it will become possible to obtain an adequate return on the capital invested in the building of a railway.

Light railways are undoubtedly a valuable supplement to the main line railways, both from the point of view of general economy and from that of traffic, and therefore they deserve to be specially studied and favoured by all those interested.

Mr. Fontaneilles. (In French.) — The report shows extremely well why it is well to take an interest in these undertakings, and to accord them some slight favours and not subject them strictly to the regulations imposed upon powerful bodies which can earn interest on their capital.

Still I think we might abbreviate these conclusions.

The President. — These conclusions are obviously too long.

Mr. Fontaneilles. (In French.) — I will try to make an abbreviation.

— **Mr. von Leber**, president, took Mr. Acworth's place in the chair.

Mr. David Cooper, Glasgow & South Western Railway, Great Britain. — Mr. President and gentlemen, I had not intended to take part in the discussion with reference to light railways. I have not had the pleasure of hearing all that has passed upon the subject, but I thought it might not be uninteresting to say a few words regarding what is being done in the matter of light railways in Scotland.

In Scotland, there are five principal railway companies. Each of the five companies has interested itself in the matter of light railways, and each of them owns a certain mileage of light railways, the total authorised being something like 140 miles.

These railways have been constructed almost entirely at the expense of the railway companies themselves. In only two or three cases has the Government been asked to give a subsidy, and it has done so to a limited extent; but so far as I am aware, they have not called upon any outsiders to contribute in any way. It may be stated, therefore, that the light railways in Scotland are constructed entirely at the expense of the railway companies, with the exception of a limited Government subsidy.

The company which I represent, the Glasgow & South Western Company, has now under construction a line of light railway from Ayr to Girvan 19 $^1/_2$ miles in length, and on the 1st of February last we opened a line from Dumfries to Moniaive 16 miles long, so that we have had as yet very little experience to report in connection with the working of light railways.

The second railway of which I have spoken, 16 miles in length, has the ordinary gauge, and connects with our main line of railway before entering the town of Dumfries. On that branch, there are eight stations with platforms of the usual height and width. We have in addition others which are put in for dealing with purely agricultural traffic.

I am sorry to say that the cost of construction of this light railway has far exceeded our expectations. It was anticipated that the cost of the railway would amount to something like between 6,000 and 7,000 pounds per mile, but it has bounded up to the abnormal figure of over 10,000 pounds per mile. This has been due to gross default on the part of a firm of borers which had not bored the ground at all over which the railway was to be made, and which had sent in a series of inaccurate reports. The result was that when the contractors came to make the line, instead of finding, as they naturally expected to find according to the borer's reports, gravel soil, sandy soil and clayey soil, they encountered boulder rock of a very difficult nature to overcome and very expensive to remove. The matter became very serious, and when it was seen that a very heavy expenditure must be incurred in making the line, the contractors and the company mutually agreed to refer the matter to arbitration. Sir Benjamin Baker, the eminent consulting engineer of London, was called in, and he decided against the railway company in the matter of expenditure and declared that the additional outlay must be borne by the railway company.

The railway, which was opened on the 1st of February, is worked by a steam motor — that is, an engine and carriage combined — which carries fifty passengers. It runs backwards and forwards about ten times a day. It only conveys passengers. The steam motor does not convey freight traffic, but on busy days and on market days, it is capable of carrying two trailers, one behind and one in front.

The cost of working, I am very glad to say, has been very materially reduced as compared with the ordinary locomotive cost. We estimated that the cost of working the ordinary locomotive with three coaches, amounted on that section of our line, to about 8 1/2 pence per mile. The result of the light railway working has reduced that cost to under 5 pence per mile, which we consider very satisfactory.

I hope these remarks will be of interest. Gentlemen, I thank you.

Mr. Fontaneilles. (In French.) — The conclusions in the reports of Messrs. Colson and Ziffer, as also the reports that the Congress has received before, show that light railways need to be subsidized. The natural thing for light railways is indeed to require assistance from public bodies. If they earned their own livelihood, it would be because they were making a good income, and under these circumstances, they would no longer be cheaply constructed railways.

Mr. Colson states in his report that the necessity for assistance from public authorities is one of the characteristic features of light railways.

The following are the conclusions I have drawn up; perhaps somebody may have some addition to suggest :

“ Light railways merit in the highest degree the attention of public authorities. Their construction should be encouraged and methods and regulations in accordance with local requirements should be applied to them. It is also desirable that State governments and local authorities should accord to light railways the support which they need so that all parts of the country may be adequately served.

“ It is, moreover, indispensable that the formula of the concession should be so defined as to harmonize the interests of the working company with those of the public. ”

Mr. Thonet, General Company for undertaking construction works, Italy. (In French.) — I should like to hear the first part of the conclusions read over again; I want to understand whether it is clearly expressed that governments or districts must take an interest in light railways by granting them subsidies.

Mr. Fontaneilles. (In French.) — I said nothing about a subsidy.

Mr. Thonet. (In French.) — You say the formula of the concession should favour the working company and the district. Consequently you imply the necessity of a subsidy. The word would be quite appropriate there.

The President. (In French.) — It would be risky to mention a subsidy, because there are countries in which there is no such thing. In Austria, it is exceedingly rare.

On the other hand, a law provides that little companies shall not be burdened by having to pay the usual taxes.

This is another form of assistance granted by the government.

Mr. Thonet. (In French.) — That is just why it would be well to lay stress on the fact that governments should concern themselves with developing this class of railway, either by subsidizing them, or by letting them off taxes which is another form of subsidy.

Mr. Lembourg. (In French.) — It would be better to speak of financial assistance.

The President. (In French.) — Indeed that would be a general expression embracing everything.

Mr. Franke, German Government. (In German.) — Mr. Colson's report is very accurate, but I should like to add that in Prussia we acknowledge it right to support lines of local interest, not only during construction but also in operation; financial assistance is, for instance, accorded them in various ways; thus, when it is a question of making junctions and joint stations, land is given them either gratis or at cost price.

On the other hand, cars are hired out to them, because these little lines are often only busy during part of the year. During the remainder of the year, these cars are not required.

At the very worst, not more than 4 per cent interest on capital is required.

Parcels and goods are transhipped gratis or very nearly so.

Further financial assistance is given.

The President. (In French.) — Do you wish the various methods of helping lines of the local interest to be enumerated in the conclusions?

Mr. Franke. (In French.) — I do not think that it is necessary.

The President. (In French.) — So the words " financial assistance " would cover everything.

Mr. Fontaneilles. (In French.) — I have drawn up another reading, Sir.

The President. (In French.) — Please read it out.

Mr. Fontaneilles. (In French.) — Here is the amended text I suggest:

" Light railways merit in the highest degree the attention of public authorities. Their construction makes it possible to encourage the progress and development of districts which previously have remained in the background, and this is not only the interest but the duty of the governments. "

Thus the principle is set forth.

" This construction must therefore be encouraged. For this purpose, it is desirable not to adhere to old types, but to introduce the methods and regulations which are best adapted to local requirements and available resources.

" It is also desirable that State governments and local authorities should accord to light railways, either under the form of subsidies, relaxation of requirements or other methods of assistance, the support which they need, so that all parts of the country may be adequately served. "

The President. (In French.) — The word " assistance " includes everything.

Do you agree, Mr. Franke?

Mr. Franke. (In French.) — Yes, Sir.

Mr. Fontaneilles. (In French.) — Here is the last paragraph which I have drawn up with a view to the advisability of considering the formula of the concession with the utmost care.

The President. (In French.) — Quite so.

Mr. Fontaneilles. (In French.) — " When the authorities of a country do not themselves construct or work light railways, and turn them over to private companies, it is indispensable that the formula of the concession should be so defined as to harmonize the interests of the working company with those of the public. "

I lay stress on this point owing to the disappointments experienced in consequence of faulty formulæ having been adopted in the earlier concessions.

It has been found that the working company was hindering traffic for its own benefit instead of developing it.

The words of advice contained in the above paragraph will then be useful to any whose business it is to work out the formulæ of a concession.

I should like to exchange for the word " regulation " used above, the words " administrative regulations " ; I suggest this in order to make it clear that we mean to ask the State to modify its regulations.

Mr. Thonet. (In French.) — What we want to make especially clear in the conclusions, is that it is necessary to simplify methods of operation.

In every country, it has taken years to get governments to accept notions of simplification as regards the operation of light and secondary railways.

Mr. Veilhan. (In French.) — We are of exactly the same opinion in France.

The President. (In French.) — We must first agree about the French text; once this is done, it would be well to raise no more objections, so that the text can be finally rendered into English and put to the vote.

Will Mr. Fontaneilles kindly read his conclusions as amended once more?

Mr. Fontaneilles. (In French.) — I suggest the following wording : “ This construction must therefore be encouraged. For this purpose, it is desirable not to adhere to old types, but to introduce the simplest methods and regulations so as to adapt them to local requirements and available resources ”

I have added the word “ simplest ”.

Mr. Thonet. (In French.) — I have no objection to raise on the principle, but I do not quite approve the shape of the conclusion. The simplest methods, you say.

That does not indicate plainly enough that all the simplifications possible in operating methods should be introduced.

The President. (In French.) — That is Mr. Franke’s idea.

Mr. Thonet. (In French.) — For the last ten years we have always been insisting that governments should introduce all the simplifications possible in operating methods.

Mr. Fontaneilles. (In French.) — Would you like me to say “ as simple as possible ” ?

Mr. Thonet. (In French.) — Excuse me; I beg you to say “ all the simplifications possible in methods of operation ”.

Mr Fontaneilles. (In French.) — We agree fundamentally. Be kind enough to draft the clause.

The President. (In French.) — We shall all agree on this point. Mr. Franke has said precisely the same thing.

Mr. Fontaneilles. (In French.) — The following is the only paragraph which gives rise to discussion ; we might say as follows :

“ This construction must be encouraged. For this purpose, it is desirable not do adhere to old types and old methods of construction, operation and regulation, but to introduce every facility possible, so as to adapt them to local needs and available resources. ”

The President. (In French.) — But there is no mention of the public authorities’ support during operation.

Mr. Fontaneilles. (In French.) — I allude both to construction and operation.

The President. (In French.) — I did not understand that operation was mentioned. Kindly read the text out again.

Mr. Fontaneilles. (In French.) — The sentence ran as follows :

“ For this purpose, it is desirable not to adhere to old types and old methods of construction, operation and regulation, but to introduce every facility possible, so as to adapt them to local needs and available resources. ”

I further say : " It is also desirable that State governments and local authorities should accord to light railways, either under the form of subsidies, relaxation of requirements or other methods of assistance, the support which they need, so that all parts of the country may be adequately served. "

That includes their construction and operation.

The President. (In French.) — That is not over clear. If I understood Mr. Franke properly, he wishes us to mention operation too.

Mr. Fontaneilles. (In French.) — Then we should have to add a very long sentence and mention construction, operation, permanent way and plant.

Mr. Thonet. (In French.) — Perhaps the text might be translated, and see whether Mr. Franke approves of it.

The President. (In French.) — Excuse me, but it is essential that we should first agree upon the French text.

Mr. Fontaneilles. (In French.) — The words :

" ... accord to light railways the support which they need, so that all parts of the country may be adequately served ", show sufficiently that we are dealing with operation; otherwise it could not be said that a government had afforded to a given undertaking the support required in order that all the districts of a country may be adequately served.

The President. (In French.) — It is rather a roundabout phrase.

If you were to say : " while they are being constructed and during the time of their operation " you could obviate all difficulty.

Mr. Fontaneilles. (In French.) — I see no disadvantage about that.

The President. (In French.) — It expresses, I fancy, the wish of these gentlemen.

Mr. Fontaneilles. (In French.) — It expresses my idea.

The President. (In French.) — Then it would be better to add those words.

Mr. Fontaneilles. (In French.) — Then we might say : " it is also desirable that State governments and local authorities should accord to light railways, either under the form of subsidies, relaxation of requirements or other methods of assistance, the support which they need either while they are being constructed, or during the time of their operation. "

That is what you wish, is it not?

The President. (In French.) — Quite so.

Mr. W. M. Acworth, *principal secretary*. (In French.) — Why only during the time they are being built and being operated?

Mr. Fontaneilles. (In French.) — It is the President's request; I am not responsible.

Mr. Thonet. (In French.) — Let us say : " both for construction and operation ".

The President. (In French.) — Be it so.

Mr. Fontaneilles. (In French.) — Then we say : "... the support which they need both for construction and operation ".

The President. (In French.) — Mr. Franke stated that cars are put at the disposal of lines of local interest. That is operation, is it not?

Mr. Fontaneilles. (In French.) — Here is the text I propose :

" Light railways merit in the highest degree the attention of public authorities. Their construction makes it possible to encourage the progress and development of districts which previously have remained in the background, and it is accordingly not only the interest but the duty of the governments to assist them. It is desirable, therefore, not to adhere to old types and old methods of construction, operation and regulation, but to introduce every facility possible, so as to adapt them to local needs and available resources. It is also desirable that State governments and local authorities should accord to light railways, either under the form of subsidies, relaxation of requirements or other methods of assistance, the support which they need, both for construction and for operation, so that all parts of the country may be adequately served.

" When the authorities of a country do not themselves construct or work light railways, and turn them over to private companies, it is indispensable that the working formula should be so defined as to harmonize the interests of the working company with those of the public. "

Mr. W. M. Acworth. (In French.) — I may say that in England hardly anyone would understand what is meant by a working formula. I would wager that in my country there are not twenty people who have even heard the expression.

The President. (In French.) — That is very sad.

Mr. W. M. Acworth. (In French.) — It may be so, but it is the fact.

Mr. Fontaneilles. (In French.) — Instead of " working formula " we might say " terms of the contract ".

Mr. W. M. Acworth (In French.) — And if there is no contract?

As a rule the Treasury allots a lump sum, *e. g.* 30 per cent of the requisite capital. In my country, there is no such definite regulation as on the continent.

If we enter into question of detail, what may apply to France or Belgium, for instance, would not apply universally!

Mr. Fontaneilles. (In French.) — I suggested saying " terms of the contract ", because that is a wider expression.

The President. (In French.) — Do not use the word contract.

Mr. Fontaneilles. (In French.) — We have been led to accept as a regulation of good administration that if a subsidy is granted to an individual or to a company a schedule of charges shall be exacted.

We might then say " the terms of a schedule of charges ".

Are subsidies granted to private companies in England without enforcing a schedule of charges upon them?

Mr. W. M. Acworth. (In French.) — No, there is always a schedule.

Mr. Fontaneilles. (In French.) — Be that as it may, I am quite content if you prefer not to mention that.

Mr. Thonet. (In French.) — At the London meeting, in 1895, we were told that in England light railways were little developed and tramways even less so. It was rightly claimed that this was due to the fact that they did not get the necessary support from the government authorities.

Attempts are being made to introduce more simple methods of working, that is, not to apply to light railways the operating methods customary in working main lines. This is what Mr. Fontaneilles himself meant. But in the last paragraph crops up the question of formula. But this is a point that is peculiar to France more especially.

It would therefore be better to say " the circumstances " or " methods " and not mention formula.

Mr. Fontaneilles. (In French.) — I think I can meet the views of everybody by suggesting the following draft :

" When the authorities of a country do not themselves construct or work light railways, and turn them over to private companies, it is indispensable that the terms of the concession should be so defined as to harmonize the interests of the working company with those of the public. "

Mr. Thonet. (In French.) — That will do very well.

Mr. Fontaneilles. (In French.) — Certain terms are generally imposed upon companies.

The President. (In French.) — The terms are quite different in each individual country.

Mr. Hugh McLachlan, New South Wales Government Railways. — I think, Mr. President, if possible we ought to make it more specific. The only point about it is this. So far as the conclusions are concerned, we agree with them; but we would like to see them a little more specific.

Generally the principle on which we undertake the light railways — not the narrow gauge, but the standard gauge — is that where there is a prospect of the light railway paying working expenses, in the first instance, and a reasonable profit after development, the government or the State always thinks it worthy of consideration. I do not know whether any basis could be laid down that would give an indication of the basis on which this Congress would think light railways worthy of consideration.

The President. (In French.) — That is a very difficult matter.

Mr. Fontaneilles. (In French.) — We cannot be precise.

Mr. Thonet. (In French.) — From what standpoint?

The President. (In French.) — There are different laws and different ordinances in every country. Thus, in Austria, there is a charter for each little line. In addition, a general law provides for financial assistance and relaxation in taxes.

In some countries, money subsidies are granted when the line is being built; in other places, subsidies in the shape of free grants of land are given; in other places again, some advantages are allowed as regards rolling stock.

In short, it is hard, not to say impossible, to be precise about the conditions of building and operating light railways for different countries.

Mr. Thonet. (In French.) — It ought to suffice to say that governments are invited to note the reports submitted by Messrs. Colson and Ziffer on question XVIII, and by Messrs. Rocca and de Tolnay on question XIX. The various terms of working in all countries are admirably summarized in these reports.

The President. (In French.) — We cannot pass conclusions dictating procedure in one fashion or another.

Mr. Thonet. (In French.) — Obviously not in conclusions, but certainly in the preamble.

The President. (In French.) — I think we all agree to pass the conclusions in the following terms :

" Light railways merit in the highest degree the attention of public authorities. Their construction makes it possible to encourage the progress and development of districts which previously have remained in the background, and it is accordingly not only the interest but the duty of the governments to assist them. It is desirable, therefore, not to adhere to old types and old methods of construction, operation and regulation, but to introduce every facility possible, so as to adapt them to local needs and available resources. It is also desirable that State governments and local authorities should accord to light railways, either under the form of subsidies, relaxation of requirements or other methods of assistance, the support which they need, both for construction and for operation, so that all parts of the country may be adequately served.

" When the authorities of a country do not themselves construct or work light railways, and turn them over to private companies, it is indispensable that the terms of the concession should be so defined as to harmonize the interests of the working company with those of the public. "

— The conclusions as read were put to the vote and adopted.

— The meeting adjourned at 12.30.

DISCUSSION AT THE GENERAL MEETING

Meeting held on May 11, 1905 (afternoon).

Mr. Stuyvesant FISH, president, in the chair.
General secretary : Mr. L. WEISSENBRUCH
Associate general secretary : Mr. W. F. ALLEN.

The President read the

Report of the 5th section.

(See the *Daily Journal of the session*, No. 7, p. 129.)

" Mr. Colson being absent, Mr. Fontaneilles (*French Government*) gave an abstract of his report.

" Mr. Colson stated that the need of financial aid for light railways is one of the characteristics of that class of railways, because the trunk systems of a country are capable of earning a revenue in proportion to the capital expended; the same is true of city lines in general. But rural lines which are intended to connect localities of small importance with great trunk lines, are seldom able to do so. It is, however, often for the public benefit to build such lines. Hence the necessity of subsidies.

" The difficulties encountered in establishing arrangements of this nature are due to two causes :

" 1° The subsidies have to be provided by different budgets. Generally, the initiative in the construction is taken by a province or a department or a district of a certain size. Frequently, the communities concerned lend their aid; finally, the aid of the State is also demanded;

" 2° It is also necessary to adjust the financial relation of the subsidizing authorities to the operating companies, for it is accepted even in the countries where the trunk lines are operated by the State that operation by private companies is more suitable for light railways. But the problem is exceedingly delicate. In fact, the most simple system is that which consists in granting to the undertaking a fixed subsidy at the outset, whether it be in a lump sum or in yearly payments; but this system has the disadvantage of giving support which may be insufficient, or on the other hand, may be more than really required. The subsidizing authorities, therefore, ordinarily prefer methods which will insure to the undertaking the support which it really needs. They are thus led to organize a sort of partnership, the regulation of which consequently offers numerous difficulties.

" One method consists in permitting the company to provide the capital and making the subsidy sufficient to insure the payment of interest on the capital (including the sinking fund) if the net earnings should not prove sufficient. This system is known as guarantee of interest. In this case, it is necessary to allow the company to retain a portion of the net earnings, without which it will never be able to get along without appealing for subsidies; it has, in that event, no interest in the results of the operation.

" It may also be arranged that the authorities furnish the capital and that the company turn over to them the proceeds of each year, after deducting a portion allowed to them as an inducement for good management. This system may be described as a profit sharing lease. Mr. Colson would express these methods by mathematical formulæ, stating that these two systems (or an intermediate system as, for example, that by which the public authority supplies directly one part of the capital, and guarantees interest on the other part) contain the principle of all the combinations used.

" He then proceeded to examine them more in detail.

" To fix the amount of the construction capital, the subsidizing authority may adopt several methods :

" It may, itself, carry on the work directly, in whole or in part. It then need not fix the amount of capital.

" It may, also, adopt the plan of contracting for a lump sum for the whole line. For instance, it may say to the management, " This line is worth 5 million francs (£200,000). " But such contracts have certain difficulties because the contractor is interested in economizing as much as possible on the amount of the contract, and may sacrifice to this consideration the future interests of the traffic. He may endeavor to expend, say, not more than 3 or 4 million (£120,000 or £160,000). Then a contract by kilometre may be adopted; that is, the amount per kilometre may be fixed, for instance, at 60,000 francs per kilometre (£3,860 per mile); but this kind of a contract also contains its difficulties, for the contractor may then try to make the line longer than necessary. We thus arrive at a contract with unit prices, so that the amount of work actually executed is paid for, and not the expenses incurred. That means, that the capital expended by the contractor is estimated on the basis of the quantity of each kind of work done : masonry, earth work, and the amount of steel used. In this way the capital is estimated, not according to the expenses really incurred, because the price paid by the contractor is unknown, but according to the quantity of work really performed by him. To induce the contractor to exercise economy, a maximum is generally fixed for the expenses, and a bonus is provided for economizing below this figure.

“ The cost of operation must also next be determined, in order to keep an account of the expenses of the contractor, if a minimum of receipts is guaranteed to him. The determination of the annual cost of operation, which the company is to receive is another very delicate question. The most simple way to determine these costs of operation is to fix a lump sum — for instance, to say to the contractor. “ We will allow you 3,000 francs per kilometre (£193 per mile) yearly, for three trains daily in both directions ”; this is the general practice in France. Mr. Colson believed that in Belgium five trains daily are agreed upon.

“ But this simple formula makes it to the interest of the contractor to avoid carrying traffic which simple increases his expenses without any return. But it frequently happens that an increase of traffic causes the company to incur expenses larger than the portion of the net receipts due to that increase, which, by the terms of the contract, is allotted to the lessee. So that a company would often have an interest in avoiding any increase in traffic at all, whenever it would entail an increase in expenses that would absorb any large fraction of the additional expenditure.

“ Accordingly, it has become common to divide up the expense to be allowed, so that a contractor gets a fixed sum and a portion of the gross receipts. This leads to a formula with two terms, $a + bR$, where a represents the fixed portion, R the gross receipts and b the coefficient. For instance, 1,000 francs + $^1/_2$ R.

“ The company has then an interest to increase the gross receipts, because it gets a fixed sum of a 1,000 francs per kilometre (£64. 7*s*. 5*d* per mile) and a portion of the gross receipts which is equal, in the suggested instance, to one-half.

“ Whatever value be placed upon the coefficient, it is always too high for merchandise of high value and light weight, and too low for heavy freight, because the cost of transportation of these materials is often far higher than half of the receipts, and the company has, therefore, no interest to develop this kind — and this is the most interesting kind — of traffic. Herein lies the great defect of the formula with two terms.

“ It has thus been found necessary to add to the preceding formula a third term proportionate to the mileage of trains run, T, which gives the formula :

$$a + bR + cT.$$

“ The coefficient c represents a fraction of the mileage cost of the extra train, 45 or 50 centimes (7*d*. or 8*d*. per mile) for instance, so that this term added to the fraction bR of the earnings going to the lessee, reimburses him his expenses, even though the train conveys only a few passengers or only heavy goods carried at very low rates. The lessee can be still further encouraged to attract these goods, by adding a fourth term proportionate to the whole ton-mileage, dK, in which K stands for the number of tons carried 1 kilometre (0.62 mile) and d a coefficient of 1 centime (0.096*d*.), for instance.

" This formula makes it possible to lead the company in the direction in which the subsidizing authorities desire it to go. In some cases, however, further terms have been added proportionate to various elements, such as the actual number of tons or passengers carried, the distance run by trains or cars of each class. This is, then, in fact, a schedule of rates which replaces a lump sum contract. A formula with five, six or seven terms instead of three is thus arrived at. These formulæ appear to be somewhat complicated, and Mr. Colson thinks a formula of three terms, if well considered in advance, suffices to insure the operation and to make it to the interest of the company to operate the road, in accordance with the public interest by attracting all the traffic that can bear a rate which will cover the cost, that is to ensure sound operation. It also happens sometimes that instead of guaranteeing to the leasing company its costs of operation on the results of a contract formula with several terms, the actual expenses of operation have been given to the company and a bonus fixed for economy. In this case, the lessor is under obligations to verify the expenses of the company. This is difficult and does not obviate the necessity for using a formula, for there must always be one so as to define a maximum expenditure that will be accepted. The difficulty in applying these formulæ consists in accurately foreseeing the consequences and in providing against the result that some unforeseen conditions may arise which would induce the company to operate the line in a manner contrary to the public interests. In France, they have now, after a tentative period, arrived at formulæ which seemed fairly to promise satisfaction to the different interests involved.

" After these general remarks, the report of Mr. Colson contains an abstract and a history of legislation regarding light railways in France, Belgium, Germany, Ireland and Great Britain.

France. — In France, the first law relating to light railways dates from July 12, 1865. This law authorizes departments to establish these roads, allotting to them, according to their wealth, subsidies of one-quarter, one-third or one-half of the sum, which the department and the other interested parties furnished. This law has been replaced by that of June 11, 1880, chiefly because it had the defect of providing subsidies for construction only and not securing subsequent operation. About that time, 1880, nearly 3,600 kilometres (2,240 miles) of light railways were consolidated with the large systems, and there remained only as light railways, constituted as such by the law of 1865, about 1,000 kilometres (620 miles), more than four-fifths of which were of normal gauge. The average cost of construction was 140,000 francs per kilometre (£9,000 per mile). These railroads were consequently not strictly speaking very cheap. Average gross receipts in 1903, about 10,000 francs (£640 per mile); net income, about 2,400 francs (£154 per mile).

" The law of June 11, 1880, substituted yearly payments for lump sum subsidies. It applies to light railways and also to tramways, but the word " tramway, " as used here, refers to light railways laid on public roads, and not to tramways in town or suburbs, for which the State never grants subsidies, provided they do not carry on an ordinary goods service. We are now speaking solely of real railways which connect different districts, the only ones that get subsidies from the State and from departments.

" These railways obtain their concession from the departments, or in cases where they do not go outside the limits of a single commune, from the commune. This latter, however, occurs very seldom. In such cases, the State grants the concession (especially where the railway is laid on a national road) to the department, and the department, in its turn, assigns the concession to the company. It requires, however, that this concession be approved by decree, which always steps in (sometimes, for important undertakings, a law) to authorize the work, and to fix the amount of subsidies by the State. The schedules for maximum rates for the companies are drawn up by the departments, but submitted to the approval of the ministers of public works, of the interior and of finance before the decree is issued. The law of 1880 provides that a subsidy of the State shall not exceed the subvention of the department and the communes. It also fixes a certain number of other maxima which are given in detail in Mr. Colson's report.

" The results of the law of 1880 have been quite satisfactory. At the end of the year 1903, there were in operation in France 9,000 kilometres (5,600 miles) of light railways (one part of them being called tramways) in addition to 1,000 kilometres (620 miles), built under the law of 1865. There are, in addition, 3,300 kilometres (2,050 miles), either under construction, or for which concessions have been granted. This represents a total of more than 12,000 kilometres (7,460 miles) of light railways. The gauge of track generally adopted is 1 metre (3 ft. 3 $^3/_8$ in.). The cost of construction of the 9,000 kilometres (5,600 miles) under the law of 1880 was 60,000 francs per kilometre (£3,860 per mile). The gross receipts in 1903 were 3,700 francs per kilometre (£238 per mile) and the net receipts about 700 francs per kilometre (£45 per mile). These roads are therefore really light railways. The number of companies which have received concessions are about a hundred, but a large number of them either belong to, or are more or less dependent on, larger companies which have made a specialty of constructing and operating secondary railroads. The earlier concessions guaranteed the company against deficits in operation, and 5 per cent on the construction capital. At present, there is no guarantee against deficits in operation, and the guarantee on the capital is 4 per cent only. Frequently, the departments themselves carry out some portion of the work with advantage, for they can utilize their engineering staff and can borrow on better terms than the companies.

" BELGIUM. — In Belgium, the construction of light railways is secured by a special organization, the National Light Railway Company, created by the laws of the 28th of May, 1884, and the 24th of June, 1885. It is a public undertaking in which are represented the State, the provinces and the communes interested. This company is privileged, for no one can obtain a concession unless the national company has refused it. It has thus the preference for all concessions. The concession is granted by royal decree. Private persons are allowed to subscribe for shares, but in general the State subscribes a large part, often one-half, and the provinces and the communes almost the whole of the rest. The society has a capital in shares and keeps separate accounts for each line.

" The State, the province and the communes are allowed, instead of paying in capital in the form of shares, to make annual payments for ninety years, which guarantee the bonds issued by the society. The administration is entrusted to a council of five members. The king names three, one of which is chairman, and the shareholders nominate the other two. There is also a supervisory council of nine members elected by the shareholders. one for each province of the kingdom.

" The society constructs the lines and then leases their operations to a contractor. Sometimes the lease is auctioned, sometimes settled by contract on private agreement. The amount of the rent to be paid is fixed by one of two formulæ, either by

$$a + b\mathrm{R} \text{ or } b\mathrm{R}.$$

" This organization has produced excellent results. At the end of 1903, the company had obtained concessions for 3,076 kilometres (1,911 miles), 2,323 kilometres (1,443 miles) of which are already in operation.

" The normal gauge is generally 1 metre (3 ft. 3 $^3/_8$ in.). The capital is on the average 53,000 francs per kilometre (£3,400 per mile). The gross receipts are 5,000 francs per kilometre (£320 per mile) and the net 1,900 francs (£122 per mile).

" GERMANY. — In Germany, the federal legislation of the empire only interferes as far as supervision is concerned and has nothing to do with the question of subsidies. It distinguishes : main lines, branch lines, narrow gauge lines.

" The narrow gauge lines and a portion of the branch lines may be considered as light railways, and the legislation of the different States of the German empire has dealt with these lines in different ways. For example, the Bavarian State Railway system, containing 1,600 kilometres (1,000 miles) of light railways, which are called local or vicinal, are of normal gauge. For these, the persons interested were required to furnish some portion of the capital. In other cases, on the contrary, concessionary companies of small lines were subsidized. Only in Prussia, small railways, as they are there called, have acquired considerable importance under a law of a special organization. The small railways of Prussia are under the law of July 28, 1892. They are divided into town tramways and secondary railways, the latter being the only ones which interest us. The latter railways have extended to 6,400 kilometres, or about 4,000 miles. Their construction must be sanctioned by the presidents of provinces. The concessions for them are given sometimes to companies, sometimes to districts and sometimes to communes. In the beginning, it was intended to leave the task of subsidizing them to the provinces, the districts or the communes, but the government has been compelled to subsidize also. On general principles, its help equals that of the provinces or districts, sometimes more. The subsidy is furnished as capital, but the State participates in the profits of operation, either as a shareholder or as a bondholder. Concessions formerly were given to companies, but there is a tendency at present to give them to districts which frequently build themselves. The bulk of the lines are leased to companies who operate them for a consideration, retaining a certain portion of the net receipts. The average cost of construction was as high as 65,000 francs per kilometre (£4,200 per mile). The gross receipts were 4,800 francs (£310 per mile), the net 1,400 francs (£90 per mile).

" United Kingdom. — Subsidies for light railways were the subject of special laws in Ireland in 1883 and in Great Britain in 1896. Mr. Colson indicates in his report that the situation has been described at previous congresses by Messrs. de Burlet, Acworth and Tatlow and that he has very little to add.

" *Ireland.* — In Ireland a law was in existence in 1883, which is sknown as the Tramways and Public Companies' Act, providing for a guarantee of interest at the rate of 4 or 5 per cent, which is to be voted by the grand jury (local county authorities). The government contributes to the guarantee of the authorities up to the extent of 2 per cent on the capital, but takes no responsibility for deficits in the receipts not covering the work of operating expenses. Under this plan, 475 kilometres, or 295 miles, of railways were built, generally of 3 feet gauge, and laid on highways; these cost 73,000 francs on the average per kilometre (£4,700 per mile), and have 4,000 francs (£257 per mile) gross receipts. The cost of operation exceeds in some cases this amount.

" In 1889, there was a second Light Railways Act in Ireland which replaced the guarantee of interest by a subsidy in capital. Under this law, there were constructed 310 miles, or 500 kilometres, of railways of broad gauge, similar to the main lines with which these connect. The average cost per kilometre is 93,000 francs (£6,000 per mile). No economical enough method appears to have been found up to the present time, for developing this secondary system.

" *Great Britain.* — The rapid development of main lines has prevented the English people from taking much trouble to facilitate the construction of secondary lines until the date of the light railway act in 1896. This act was intended to reduce very considerably the formalities which made the building of railroads so difficult. Permission to construct the line can be granted by the Board of Trade instead of by parliament. The procedure is simplified especially as far as compulsory purchase is concerned.

" As to subsidies, the law authorizes county councils, districts and cities to borrow money to subsidize light railways. It authorizes the treasury to make advances to them. Finally, in certain cases, to give subsidies up to one-half of the construction capital. Under this plan, besides some suburban tramways, there have been constructed some real light railways for agricultural districts, the only ones which interest us. Many projects have been under consideration, but all have not been carried out; the necessary capital is difficult to obtain for a great number of these enterprises for several reasons, especially because of their high cost, which is estimated to be on the average of 91,000 francs per kilometre (£5,860 per mile). It is possible that they would prove not sufficiently economical to develop easily.

" Mr. Colson's report ends here. It does not contain conclusions, properly speaking. It contains rather a general summary. It is quite difficult to establish fixed rules for such matters. These are not technical questions; they are rather of a special kind.

" Mr. Veilhan (*French Light Railways*) remarked that the Western Company of France has made considerable economies in leasing to small companies some of its unproductive lines. It has been found that the small companies can operate cheaper than the larger. The service expected from large companies is not insisted upon from the smaller ones, and considerable savings are thus made.

" Mr. Ziffer, reporter for countries other than France, Belgium, Germany and the United Kingdom, being absent, Mr. Lembourg (*Belgian Light Railway Company*) read an abstract from his report.

" Mr. Ziffer in his report reviews the countries not mentioned in Mr. Colson's report. In some of these countries, there has been no legislation; in Bulgaria, the Congo State and Spain, where bills have been introduced but have not become laws. In the United States, it may be said that what are called in Europe light railways do not exist. In Portugal also, there are no legal provisions on the subject, nor are there any in Russia or Uruguay.

" In Turkey, however, the railways may all be regarded as light railways and a minimum amount of gross receipts is usually guaranteed by the State.

" In the Argentine Republic, the government goes only so far as to grant free occupancy of the necessary land.

" In Austria, it is at times the kingdoms or provinces of which the monarchy is made up that themselves get the concessions and then build and work the lines. The State subsidies assume various forms. Sometimes a profit is guaranteed or shares of the stock are taken—which is remarkable, because in other countries the government usually takes bonds. Usually, also, the lines are taken over for State operation at a price very favourable to the small lines. Sometimes the State undertakes the construction for the account of local railways, employing the most economical methods possible. When the State guarantees the capital of a light railway, it usually builds and works the road itself. When local authority guarantees, the line is generally built by the district in question and operated by the State. In Lower Austria, the local authority not onlybuilds, but also operates the railways.

“ In the case of Bohemia, 34 local lines have been built, with a total length of 1,122·7 kilometres (697·6 miles), and a capital outlay of 137,215,468 francs (£5,488,618.14*s*.). The kingdom has contributed in the form of loans and preferred stock 73 per cent; the State, in the form of subscription to capital stock, 7 per cent, and other interests 20 per cent.

“ Mr. Ziffer spoke in his report of the traffic of the Bukowina Local Railway, 82 per cent of which consists in transporting timber of various kinds, 6 per cent building materials and 5 per cent wheat and flour. Of the gross receipts, 14 per cent comes from passenger traffic and 86 per cent from freight.

“ In Hungary, the financial assistance from the authorities usually consists in subscribing up to 15 per cent of the common stock; 65 per cent must be contributed by the company as preferred stock.

“ As a rule, the lines are operated by the management of the State Railways, on the basis of refunding actual expenses.

“ In Denmark, the State has assisted by guaranteeing 4 per cent on the capital invested, including the cost of purchasing the land. But, in certain cases, the purchase of the latter is left to the parties interested to prevent an excessive appraisal of the land. Since the law of 1894, the State contributes one-half or three-quarters of the expense.

“ In Egypt, the free use of the land in granted and the government also allows a net sum of 900 francs per kilometre (£58 per mile), but this guarantee is of no practical value, because of its very trifling amount.

“ In Italy, the system of subsidies also prevails. This system has been modified by different laws. At first, the subsidy did not exceed 1,000 francs per kilometre (£64 per mile), by the law of 1873, but the law of 1881 raised the amount of the subsidy to 3,000 francs per annum per kilometre (£190 per mile), and even later to 8,000 francs (£510 per mile). It is now 6,000 francs (£380 per mile).

“ In Norway, there has been no general legislation on this subject. Special subsidies are stipulated for each line. Very often the State agrees to assume one-half of the cost of construction. One-half of this portion takes the form of a subsidy, the other half being represented by shares or stock.

“ In the Netherlands, the financial assistance of the State and provinces is not defined by any general law. Each separate concession is dealt with separately. In the Dutch Indies, the intervention of the authorities is confined to allowing the free use of the roads. The same is the case in Roumania.

“ In Servia, there is also a law which, up to this time, has had of application. The principle of the law, is that materials intended for the construction on light railways are exempt from duty.

“ In Switzerland, there is no general law specifying that subsidies be granted, but some cantons have given aid in the form of subscribing for shares. Under this category comes the Rhetic Railway, which has just gone into operation; the Confederation has subsidized it by subscribing for deferred shares; the Grisons canton has subscribed for ordinary shares and has furthermore guaranteed the interest on the debentures issued.

" Mr. David Cooper (*Glasgow & South Western Railway*) stated that there are in Scotland about 140 miles of light railways which have been constructed almost entirely without subsidy from the government. He gave some data regarding a line 16 miles long, which was built by his company, and, for unforeseen reasons, cost £10,000 per mile. It is worked by a steam motor — that is, an engine and carriage combined — which is capable of hauling two trailers.

" Mr. Hugh McLachlan (*New South Wales Government Railways*) inquired if it was not possible for the section to define more specifically the conditions under which a railway should be built and operated as a light railway.

" Mr. Franke (*German Government*) said that Mr. Colson's report was very accurate, but he wished to add that the Prussian government assists light railways in the operation, as well as during the construction. It grants, for instance, the free use of land for stations, and leases the cars, requiring only 4 per cent interest, and tranships baggage and freight free of charge or nearly so.

" The following conclusions were adopted, to be submitted to the general meeting. "

The President. — The following are the

CONCLUSIONS.

" Light railways merit in the highest degree the attention of public authorities. " Their construction makes it possible to encourage the progress and development " of districts which previously have remained in the background, and it is accordingly not only the interest but the duty of the governments to assist them. It is " desirable, therefore, not to adhere to old types and old methods of construction, " operation and regulation, but to introduce every facility possible, so as to " adapt them to local needs and available resources. It is also desirable that State " governments and local authorities should accord to light railways, either under " the form of subsidies, relaxation of requirements or other methods of assistance, " the support which they need, both for construction and for operation, so that all " parts of the country may be adequately served.

" When the authorities of a country do not themselves construct or work light " railways, and turn them over to private companies, it is indispensable that the " terms of the concession should be so defined as to harmonize the interests of the " working company with those of the public. "

— These conclusions were adopted by the general meeting.

MISCELLANEOUS INFORMATION

[625 .143.4]

1. — The double sleeper joint and the creeping of rails.

Figs. 1 and 2, pp. 248 and 249.

(*Zeitung des Vereins.*)

Of all the devices invented and used for preventing the objectionable creeping of rails, there are only three which have given more or less satisfactory results, namely : *a*) the butting fishplate; *b*) the Dorpmüller wedge-cramp; *c*) the double-sleeper joint.

We assume the two former known; we will only mention that occasionally even with metal superstructures butting fishplates taking against and secured to the sleepers have proved quite unsatisfactory; it may be remarked that their use on old tracks is troublesome owing to the holes which have to be drilled. We may also state that these two devices do not give a good fastening. In this note we shall therefore only consider the double sleeper joint.

If we reflect that the double sleeper is the only one of the innumerable improvements of the track which besides preventing creeping also has the invaluable advantage of giving a good and durable joint, it seems almost surprising that its use has not by now become more extended.

The double sleeper consists of two iron sleepers of ordinary pattern, the usual distance apart, joined together by two bridge-pieces so as to form one united whole. The bridge-pieces which are immediately below the rails have the same cross sections as ordinary iron sleepers (fig. 1). Formerly the top of the bridge-pieces was sometimes lower than the bottom edge of the rail, sometimes of the same height; to-day the latter arrangement is preferred for practical reasons, with an inclination of 1 in 20, so that a supported joint results.

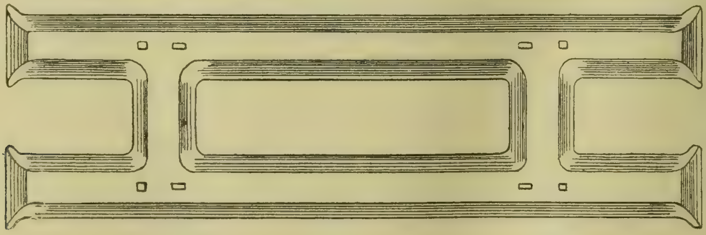

Fig. 1.

According to information supplied by Messrs. Breuer, Schumacher & Co., of Kalk near Cologne, who hold the patent rights, the use of the sleepers in question had at the end of 1905 the extent shown in the annexed table.

Index number.	Number of double sleepers laid.	PLACE.	NAME OF PURCHASER.	Narrow gauge.	Standard gauge.	TIME OF DELIVERY.
1	1,000	Aix la Chapelle.	Aix la Chapelle local line	Narrow gauge.	...	1898.
2	522	— —	— —	—	...	October, 1902.
3	2,000	— -	— —	—	...	1905.
4	6	Carlsruhe.	Tramway.	—	...	?
5	90	Stettin	—	—	...	June, 1905.
6	15	Freiburg	—	—	...	July, 1903.
7	30	—	—	—	...	November, 1903.
8	200	—	—	—	...	August, 1904.
9	100	The Hague	Dutch colonies	—	...	October, 1903.
10	10	Barmen	Tramway.	—	...	August, 1904.
11	67	Cologne-Brück	Local line.	—	...	May, 1905.
Total : 4,040						
12	450	Magdebourg	Tramway.	...	Standard gauge.	November, 1900.
13	250	—	—	...	—	August, 1904.
14	200	—	—	...	—	April, 1905.
15	60	Mayence	Royal and Grand Ducal Management	...	—	June, 1901.
16	50	Berlin	— Management	...	—	February, 1902.
17	60	Lucerne	St. Gothard Railway	...	—	August, 1903.
18	250	Utrecht	Dutch State Railway	...	—	May, 1904.
19	60	Berne	Swiss Federal Railway	...	—	December, 1903.
20	100	Stuttgart	Wurtemberg State Railway	...	—	October, 1904.
21	500	Munich	Bavarian State Railway	...	—	May, 1905.
22	230	Saint-Goar	Royal Cologne Management	...	—	June, 1904.
23	310	Boppard	— — —	...	—	June, 1904.
24	108	Oberhausen	— Essen —	...	—	June, 1904.
25	93	Camen.	— — —	...	—	June, 1904.
26	138	Wetter	— — —	...	—	June, 1904.
27	101	Ratingen	— Elberfeld —	...	—	June, 1904.
28	200	Gr.-Königsdorf	— Cologne —	...	—	July, 1904.
29	170	Ratibor	— Breslau —	...	—	July, 1904.
Total : 3,330						

Remarks. — **No. 15** : This trial section, which forms part of the Mayence-Francfort on the Main, where there is very heavy traffic, was laid nearly five years ago. No defects are yet visible; the fishplates and rails show no visible wear.

No. 16 : Laid more than three years ago, just before a station, where the brakes are often used; the double sleepers give exceptionally satisfactory results. Accurate measurements taken at three points show that the creeping, since they were laid, has not exceeded 8 to 14 millimetres ($^5/_{16}$ to $^9/_{16}$ inch). Moreover, the ballast on the trial section has not been repacked except under the intermediate sleepers; the joint sleepers have not been touched. Nevertheless, their action is perfect.

No. 17 : The purchaser desired that there should be a small depression in the bridge-pieces immediately below the joint (*a*, figure 2), so that the flanges of the rails should not cut into the sleeper. It is to be noted that the engineers now state that this depression has already affected the wear of the fishplates and that in future they will only order double sleepers with smooth top, so that the rails may be supported over their whole length.

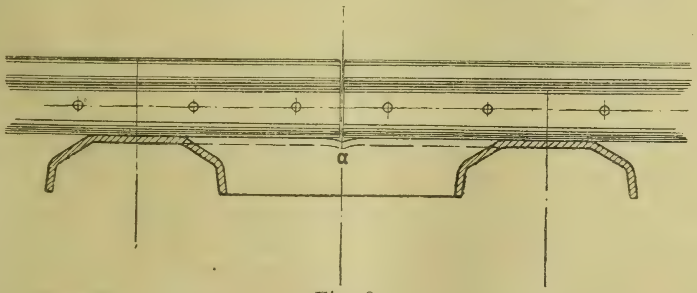

Fig. 2.

Nos. 22 and 23 : This section, where there are many curves, and where the traffic is exceptionally heavy, has given excellent results.

No. 25 : On the Dortmund-Hamm section, where the traffic is probably heaviest, half the sleepers are on broken stone, half on gravel. Rail 9, with lapped joints. Up to the present, the track is in very good condition; there has been no creeping.

No. 28 : Cologne-Aix la Chapelle section; ballast (*grauwacke*). Fixed datum points, marked for the purpose, show that there has been no creeping.

As a predecessor of the pressed double sleeper now used, we may mention the rolled double sleeper proposed by Gelbcke in 1891 (see *Zentralblatt der Bauverwaltung,* 1891, pp. 61 to 63), which was to be laid, instead of the ordinary sleepers, 1·5 metres (4 ft. 11 in.) apart.

As Gelbcke himself states in the *Zentralblatt der Bauverwaltung*, 1905, pages 433 and 434, the trial section, 90 metres (98 yards) long, laid November 1891, between Mehlem and Rolandseck, did not give good results because the middle connecting plate, which was trough-shaped and extended 120 millimetres (4 $^{23}/_{32}$ inches) under the top plate, rested too much on the ballast and consequently the sleepers were liable to oscillation. The sleeper was too wide and the middle dipped too deep into the ballast.

The double sleeper made in 1902 by Gelbcke by riveting together two iron sleepers pattern 51*a*, and laid on the single track Ratibor-Leobschütz line, cannot have been of the pattern illustrated in the *Zentralblatt der Bauverwaltung*, 1905, page 434.

When Gelbcke states that up till now, the cost of maintenance has not shown any appreciable difference as against the ordinary rail-joint, that is, to begin with, no recommendation for his double sleeper, for all the trial sections equipped with the Kalk double sleeper already show, in the opinion of all the engineers concerned, that materially less maintenance is required than with any other type of joint. This difference in the cost of maintenance is very intelligible, for with the Gelbcke sleeper the length of rail supported is only 270 millimetres (10 $^{5}/_{8}$ inches), whereas 100 millimetres (3 $^{15}/_{16}$ inches) of the intermediate length are suspended. With the Kalk sleepers, on the contrary, the length of rail supported amounts to 650 millimetres (2 ft. 1 $^{5}/_{8}$ in.). Now when the supporting surface is larger, the fishplates and the surfaces in contact with them are less strained; there is consequently less movement vertically and less wear. Moreover, the turned down portions of the double sleeper ensure that the track is more firmly supported by the ballast. If those are missing, transverse movements result and involve maintenance expenditure.

Similarly when Gelbcke states that the ends of the rails suffer less at the joints than in the case of ordinary rail-joints, with simple sleepers, and that the wear is more uniform, this does not seem any great recommendation, for on the experimental sections equipped with Kalk double sleepers, the wear observed is as great at the middle of the rails as anywhere else. Moreover, it might be necessary not only to determine the outward visible wear, but also that hidden by the fishplate, and to examine the state of the fishplates themselves.

The Kalk double sleepers ordered for the last more extended trials on the Prussian State Railways, had the necessary inclination produced by the press; they were designed for the use of simple holding-down plates, not of cramp plates. As the inclination required can be produced by the press with much accuracy, there is a great simplification by eliminating the cramp plate, and placing the rail on the sleeper direct and securing it by holding-down plates. Any vertical movement of the fishplates is thus eliminated, and all the latter have to do is to connect the rails at the joint and assist in resisting lateral forces. It has in fact become apparent in the course of years, that in spite of continually strengthening the fishplate, in length, width and depth, it was not possible to prevent the quick wearing of the fishplates and of the rail surfaces in contact with the fishplates, because no effective remedy was known. Only in the Kalk double sleeper has a means been found to protect the rail and the fishplate against untimely wear.

In the case of the ordinary suspended joint, the fishplates and the surfaces in contact become worn irregularly; it is at the middle of the joint, that is to say, at the middle of the fishplates and at the ends of rails, that wear first begins and is most intense. For this reason, it becomes impossible, after a short time, to tighten up the fishbolts effectively, for the unequal wear of the fishplates and of the surfaces in contact prevents a sufficiently large area from being in firm contact, even though inclined surfaces are provided for the purpose. Once the original flat surfaces have become deformed, they can no longer be returned to their original condition, and hence there is no possibility of good fishing.

Matters are quite different in the case of the double sleeper. On the experimental section of the Mainz District, where by June 1906 the double sleepers had been in use for five years, under heavy traffic, the fishplates showed no wear. That is just the great advantage of the double sleeper over Gelbcke's sleeper. For Gelbcke himself states that he must use heavy fishplates in order to obtain a good joint, and this proves that his sleeper does not give sufficient strength vertically and that the fishplate has to supplement this deficiency. The solid support afforded by the double sleeper results in very feeble wear of the rails, sleepers, fishplates and other accessories. The resulting saving much more than counterbalances the higher prime cost of the double sleeper. The numerous trials made show this conclusion to be definitely correct. On the other hand, the Gelbcke sleeper is by no means as good as the double sleeper, as regards safety. In addition there are the simplicity of the supervision, the smooth running, the good draining and the good preservation of the ballast, the reduction in the stresses the rails are subjected to (they consequently do not get crushed); finally, there is the great advantage that the double sleeper can be used on any type of track with transverse sleepers, without the need of renewing the sleepers or the rails.

The following calculation will show the economy which may result from the use of double sleepers. When double sleepers are used, the saving which results from the use of shorter fishplates, and the elimination of the butting plates and the bedplates, in the case of 12 metre (39 ft. 4 in.) rails is as follows :

a) $^1/_3$ of the fishplates and bolts . . . $\left\{ \frac{6{\cdot}80 + 1{\cdot}80}{3} \left(\frac{6s.\ 9{\cdot}6d. + 1s.\ 9{\cdot}6d.}{3} \right) \right.$	= 2·90 marks	(2*s*. 11*d*.)	approximately.
b) 2 hitting plates and their bolts	= 4·00 —	(4*s*.)	—
c) 4 bedplates	= 2·30 —	(2*s*. 3 ½ *d*.)	—
Total	9·20 marks	(9*s*. 2 ½ *d*.)	approximately.
1 double sleeper costs	28·00 marks	(£1. 8*s*.).	
2 joint sleepers costs	12·30 —	(12*s*. 3 ½ *d*.).	
Difference . , ...	15·70 marks	(15*s*. 8 ½ *d*.).	
Deduct total as above . .	9·20 —	(9*s*. 2 ½ *d*.).	
There remains.	6·50 marks	(6*s*. 6*d*.).	

as the additional cost per double sleeper.

The saving in maintenance has also to be considered. If the joints creep to any extent, they must on the average be readjusted four times a year. Cost of labour : four men, each working about one hour, cost about 1·2 marks (1*s*. 2 ½ *d*.); or adding wear of tools and repacking of ballast, about 2 marks (2*s*.), or per annum 4 × 2 = 8 marks (8*s*.).

A double sleeper, even if laid very carelessly, requires attention at most once a year. Four men are required, working about half an hour each, cost 0·6 mark (7 ½ *d*.) per annum; wear of tools and repacking of ballast (hardly ever required), at most 0·2 mark (2 ½ *d*.); total 0·8 mark (10*d*.) per annum. The yearly saving in maintenance is thus 8 — 0·8 = 7·2 marks (7*s*. 2*d*.).

As putting in a double sleeper only costs 6·5 marks (6*s.* 6*d.*) more, the greater prime cost is more than repaid, in the first year already, by the saving in maintenance. To this we must add the saving in maintaining the rolling stock which becomes less worn as the joints are stiffer; it is difficult to determine how much this saving amounts to. But the rough calculations given above supply strong evidence that the use of double sleepers is economical as compared with the use of ordinary joint sleepers.

It is not necessary to work out what economy the double sleeper shows as against the Gelbcke sleeper, even when used as intermediate sleeper. A trial would probably involve so much expense that it would soon be given up. Moreover, there is no reason why the Gelbcke sleeper should be adopted as intermediate sleeper; for as the high-speed trials on the Marienfelde-Zossen line have shown, the new standard sleepers of the Prussian State Railway are stiff enough to make a good track. Now the numerous trials made show that efficient and safe joints are best obtained by the use of double sleepers, and such joints are a great desideratum on any kind of line.

A document which shows conclusively how good the double sleeper is considered by the engineers concerned, is supplied by the minutes No. 81 of the meeting September 14-16, 1905, by the technical committee of the German *Verein*, at Tátra-Lomnicz, page 30 : " The double sleepers manufactured at Kalk are reported on by five managements. The Berlin and Mayence managements state that the results are undoubtedly satisfactory. The three other managements do not yet express any definite opinion, as the period of observation is too short. " These three are the Essen and the Kattowitz managements, and the Wurtemberg State Railway. Moreover, it is stated on page 31 : " The Mayence management is of opinion that the Kalk double sleeper is an effective means for preventing the creeping of rails. "

It is to be hoped that the concluding request, on page 32 : " The meeting decides to call on the managements belonging to the *Verein* to continue the present trials and to construct more trial sections ", will be fully complied with. It would perhaps be advisable to supply to each of the managements a sufficiently large number of double sleepers (at least 500), to be tried where local and traffic conditions are most severe. The many satisfactory trials made on the small scale no doubt incite to more extended trials, which it seems to us will be conclusively satisfactory. The following instances may be suggested as experimental sections with steep down grades : Aix-la-Chapelle-Ronheide, Erkrath-Hochdahl, Elberfeld-Cronenberg, Vohwinkel-Solingen, the Nahe line, the Black Forest line, the Bingen-Cologne lines on both banks of the Rhine, the Arnsberg-Cassel section of the Ruhr Valley line, the ramps to the Rhine and Vistula bridges, etc.

In conclusion, we would quote sundry other articles which definitely recommend the use of double sleepers, as present experience shows that there are no other means for making good joints. In an article entitled " Long distance express trains with a maximum speed of 120 kilometres (74·6 miles) per hour," published in the *Zeitung* for 1905, we find on page 1458 :

" To judge by the results obtained up to date, the track known as the " express train track ", with rails 12 metres (39 ft. 4 in.) long, weighing 41 kilograms per metre (82·65 lb. per yard), laid on eighteen sleepers, seems to be sufficiently strong for long distance express trains and, to resist the static and dynamic forces involved without permanent deformation. If it should however prove in the long run to be too weak, it would become necessary to strengthen the joints, the rails and the sleepers and to improve the ballasting. Mr. von Borries draws attention to the importance of the magnitude of the masses, wheels and rails acting on each other, and taking the laws of impact into consideration, he asks that the greater part of the blow produced in running over a joint should be taken up by the superstructure; he arrives at the conclusion that there must be a certain ratio between the mass of the rail and that part of the mass of the vehicle which is not supported on springs (axles and axle-boxes). But this becomes quite unnecessary if the joint is so constructed that no shock results when vehicles run over it. Designers are continually trying to solve this problem, but in many of their joints they seem to neglect the principle of simplicity in construction... In every joint it is primarily necessary to prevent effectively any relative movement of the constituent parts when rolling loads pass, or else wear results which in its turn conduces to the slackening of the joint under the action of the dynamic forces. If it is moreover desired that the joint, while satisfying this condition, should also be subjected to the same elastic deformation as the rest of the rail, the problem becomes still more difficult. The number of different joints which exist are the best proof that the problem has not yet been solved. If the very ingenious devices built up of many pieces have not behaved as expected, this is chiefly due to their design, in which the question of uniform wear has not been sufficiently considered. This is easily proved by calculating the stresses some of the surfaces of such joints have to resist.

" The attempt to stiffen the joint leads to giving up suspended joints and adopting bridge joints, which are a compromise between suspended and supported joints. When we try to avoid the bridge, which is costly and cumbersome, we arrive, by bringing the two joint sleepers together, at the two-sleeper joint, which represents a phase often observed in technical evolution, consisting, in this case, of passing from the supported joint through the suspended joint back to the supported joint. As up to now all joints have proved weak in the long run, this conclusion must be drawn : no joints with many parts, costly to make, put in and maintain ; but a simple joint, consequently inexpensive and easy to put in and maintain. "

The double sleeper, which firmly combines in one piece two joint sleepers at the ordinary distance apart, satisfies the conditions specified in the preceding article for a good joint much better than the two-sleeper joint, all the more so as a much greater mass of ballast, which can also be drained more easily, helps to resist the creeping and the shocks produced by traffic.

Dr. Haarmann (p. 120 of the *Zeitung*) stated at the January meeting of the *Verein für Eisenbahnkunde*, at Berlin, that in the definite improvement of railway tracks, high initial cost is of less importance than continuous economic success; if we agree with him, then the higher initial cost of the double sleeper, as compared with the ordinary arrangement, is no reason against the more extended trials suggested above. We are definitely of opinion that the most optimistic expectations as to the stiffness of the joints and as to creeping, will prove to be realized.

Finally, in an article entitled " Results obtained on a track with reinforced joints, on wooden and metal sleepers, " published in the *Zeitung*, pages 290 to 292, we read that " the track with reinforced joints on metal sleepers is a good step in advance in the problem of a good permanent way, a problem as old as the railway itself, and which it has been tried to solve in very different ways. " That is a conclusion which one cannot but approve. Then the author of the article adds : " It is to be hoped that trials and observations will be made of other joints and systems of superstructure, so that an absolutely perfect system may be worked out; this is a prime need if a regular service of express trains is to be organized. " This hope, which we cordially endorse, justifies the desire expressed above that much more extended trials may be made with double sleepers than have been made in the past.

The *Zeitung* states in No. 29, page 474 and 475 (¹), that on the experimental section, 1,756 metres (1 mile 160 yards) long, near Oranienburg, four different types of track are going to be tried : 1° rails 8*b* with strong suspended joints; 2° rails 9*b* with strong lapped joints; 3° track with Haarmann strengthened joints; 4° rails 8*c* with Becherer and Knüttel joints. Let us hope that the double sleeper will at least be tested in the second series of trials, even if it should not be possible at present to test a considerable number of these sleepers and compare them with the pine, oak, beech and ordinary iron sleepers which it is proposed to test now.

[**621** .152.5]

2. — " Prairie " type compound engines at Milan Exhibition.

Fig. 3, p. 257.

(*The Engineer.*)

The *Prairie* type — or 2-6-2 — locomotive, promises to be admitted into the regular practice of the Continent, as it is also in America, but to a more restricted extent, for while in the United States, the driving-wheels may carry loads of 170,000 lb., in Europe the existing limits of from 105,000 to 118,000 lb. would necessitate another wheel arrangement, or, in other words, another wheel type for very heavy locomotives. The main object of the *Prairie* type is to concentrate the greatest possible weight upon the driving-wheels, the total number of wheels being limited to ten. Examples of this type are in regular service in Austria and Italy, and it is precisely in these countries that the wheel loads are least — never exceeding 95,700 lb. for the three axles. Mr. Goelsdorf, of the Austrian State Railways, was the first to introduce this type — January, 1905 — for working express trains on continental railways. Although it is an economical design with only one pair of leading wheels, it does not fulfil every condition necessary for fast passenger services, and one noted locomotive builder of the Continent — Maffei — has now passed over this type in introducing yet another American type — the *Pacific* — in which the leading four-wheel bogie is retained, and a wheel arrangement of 4-6-2 obtained.

In service on the Austrian railways the four-cylinder compound *Prairie* type engine of Mr. Goelsdorf can pull trains of 400 tons up gradients of 1 in 100 at the rate of 34 miles per hour, and in trials has run at all speeds up to 74 miles per hour with remarkable smoothness. It is intended for the heaviest of Austrian trains, and for all grades up to 1 in 50. This engine was exhibited at Milan, and is illustrated on the next page.

The arrangement of the engine is of the usual Central European type, with all cylinders in line, and all connecting-rods working upon one pair of driving wheels. All the cylinders are placed at an inclination of 1 in 8. This is necessary so that the inside crossheads may clear the leading coupled axles. The outside cylinders are placed at the same angle, in order to simplify construction. The cylinder castings are in one piece for each pair of high-pressure and low-pressure cylinders, the two castings being bolted together in the centre line of the engine, with the low-pressure cylinders outside as usual. There are, of course, only two valve mechanisms for the four cylinders.

The valve gear is the normal Heusinger — or, as we call it, Walschaerts's — arrangement for

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(¹) See *Bulletin of the Railway Congress*, No. 8, August, 1906, p. 1340 : « Experimental track for trials of superstructures and ballast ».

slide valves, and therefore as the rocking transmission from the outside to the inside valves must necessarily cause the inside valves also to admit steam by their outside edges, a special arrangement of reversing rocker is employed, this being common, with but slight differences, to all the four-cylinder engines of the Austrian State Railways. There is no intercepting valve, as the engines always work compound, but in the seatings of the low-pressure valve chests there are orifices — Goelsdorf's patent — which permit live steam to enter the low-pressure valve chests automatically whenever the reversing gear is set forward in the usual starting positions. For the realisation of the fullest advantages in compounding, ad moderate piston speeds, the ratio adopted here for the cylinder volumes, high-pressure to low-pressure, is 1 : 2·93. The same proportion is maintained for new goods engines using superheated steam and higher steam pressures.

The crank axle is of the oblique type, with all journals and crank pins bored out hollow. The material employed is special crank steel from the Neuberg works of the Alpine Montan Gesellschaft. The straight axles are of Martin steel, containing 1 per cent. of nickel, obtained from the Ternitz works of Schoeller & Co. The wheel centres are steel castings — Martin process — from the steel works of Witkowitz, and the crucible cast steel tires are from the Ternitz works. The boiler plates and frame plates of Martin mild steel are from the Zeltweg Works of the Alpine Montan A. G. The tubes also are of mild steel — *flusseisen* — from the Komotauworks of the Mannesmann Rohrenwerke, and the copper sheets for the fire-box are from the Kamenitz works of Franz Ringhoffer.

The engine is fitted with two Friedmann oil pumps, lubricating all pistons, slide valves, and the rear packings of the high-pressure pistons inside the frames; two suction injectors of Friedmann's model S. T.; the Rihosek steam sanding apparatus; Marek's smoke-consuming and coal-economising air register in the fire-door; Hausshaelter's speed indicator and recorder; steam train heating apparatus with Foster's reducing valve, and the vacuum rapid-acting (1902) brake operating upon all the driving-wheels, but not on the bearing wheels, which in this engine have radial axle-boxes of Adams' type.

The engine was built by the Wiener Lokomotiv-Fabriks at Florisdorf, and is finished in a style which can only be termed severely mechanical. It is classed " Series 110. "

The following are the leading dimensions and particulars :

Cylinders, high pressure, two.	14 $^{1}/_{2}$ inches.
— low-pressure, two	24 $^{7}/_{8}$ —
— piston stroke	28 $^{1}/_{2}$ —
Driving wheels, diameter	71 $^{5}/_{8}$ —
Boiler pressure	220 $^{1}/_{2}$ lb.
Heating surfaces, fire-box	147·4 square feet.
— — tubes (No. 282)	2,625 — —
— — total	2,772·4 — —
Tubes, length	17 ft. $^{3}/_{4}$ in.
— diameter, inside and outside	1 $^{7}/_{8}$ inch and 2 $^{1}/_{16}$ inches.
Grate area	43 square feet.
Bearing wheels, diameter	40 $^{3}/_{4}$ inches.
Rigid wheels, base.	3·900 metres (12 ft. 9 $^{9}/_{16}$ in.).
Total, — —	9·490 — (31 ft. 1 $^{5}/_{8}$ in.).
Adhesion weight, maximum	42·9 metric tons (42·2 English tons).
Engine weight, empty	61·8 — — (60·8 — —).
— — fully loaded	68·9 — — (67·8 — —).

The tender is carried on six wheels. It is suited to the special order of service for which the engine is designed, and weighs empty only 14 tons. It carries 3,685 gallons of water and 8 $^1/_2$ tons of coal, and fully loaded weighs 39 tons. It has the improved trough-fillers projecting from each side of the tender and extending the whole length of the sides.

[625 .255]

3. — Acetylene car lighting on Great Northern Railway (United States).

Figs. 4 and 5, p. 258.

(*Railway Age.*)

The Great Northern Railway which has had a great deal of experience with the practical use of acetylene gas for car lighting, having started to apply it as early as 1899, has adopted an individual gas generator for each car, a description of which it as follows :

The generator, of which 75 to 100 are now in daily service, takes up very little room on the car, and consists of a 12-inch cylindrical shell extending from below the floor of the car up through the roof, there being nothing but permanent connections within the car. A charge of 150 pounds of calcium carbide is put into the generator from the roof of the car. The water tank holding a sufficient supply of water has an extension up through the roof where water is also supplied from without. An outlet is provided beneath the floor of the car for cleaning out the residue at the end of long runs, or after four or five nights' heavy service, as cars equipped with these generators are in trans-continental service as well as running on remote branch lines. When the car equipped with this generator leaves the terminal, the train crews and porters light or turn off the gas in the same way as would be done at a city residence ; the generator supplies the gas according to the consumption. All attendance to the generator is done by the car men while the cars are in the yards being cleaned.

Figure 4 shows the interior of a second class coach with gas generator installation, the cylindrical generator passing through the car from floor to roof, the water tank over the door, the condenser in the corner of the clear deck, gas outlet pipe from the generator to the bottom of the condenser, and gas pipe coming out the side of the condenser. A cut-out cock is shown on the gas pipe to the condenser, for cutting off the generator at terminal when being charged. These generators are inclosed in closets on first class cars, or placed in one corner of saloons, if desired, as they take up very little valuable floor space.

The figure 5 shows the generator applied to a coach. The generator has its carbide chamber at the top extended downward about 3 feet, and terminating in a grating to form the bottom of this receptacle. The bottom being filled with water and connecting with the overhead supply tank, the water rises up to the grate where it comes in contact with the carbide, generating gas and at the same time slaking the carbide ; the residue drops down to the bottom of the generator. The gas forms a slight pressure above the water, causing it to recede until the gas is sufficiently drawn off in using, thus automatically regulating the making of gas according to the consumption.

The other accompanying apparatus used does not complicate the installation as a whole ; it includes a condenser, a storage reservoir and a regulator to insure pure dry gas at a steady pressure.

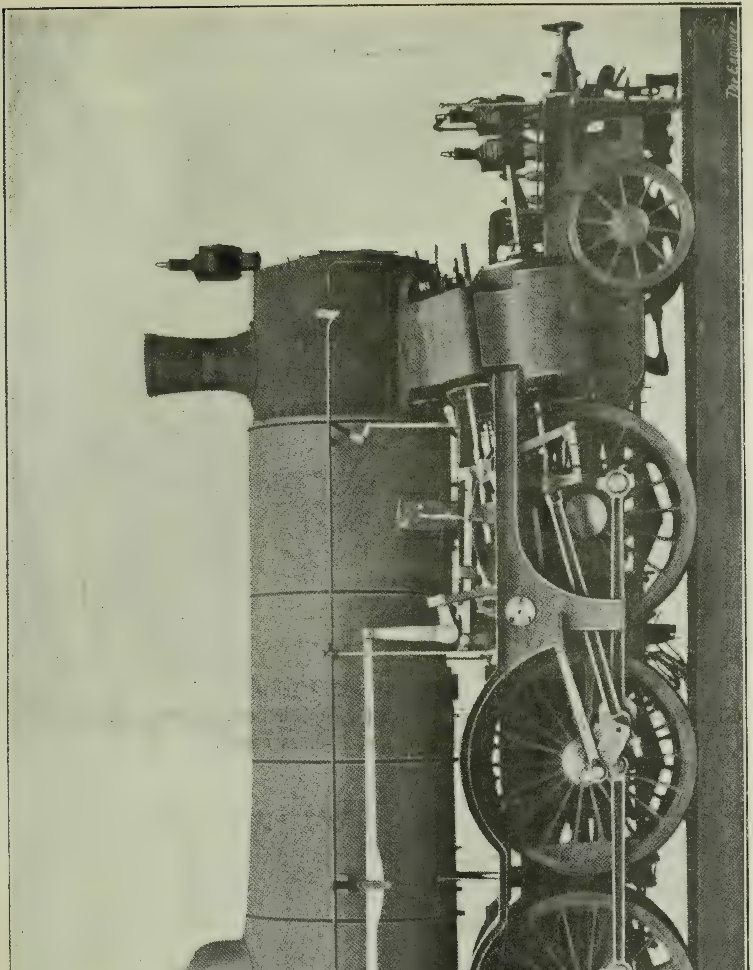


Fig. 3. — Compound locomotive, Austrian State Railways.

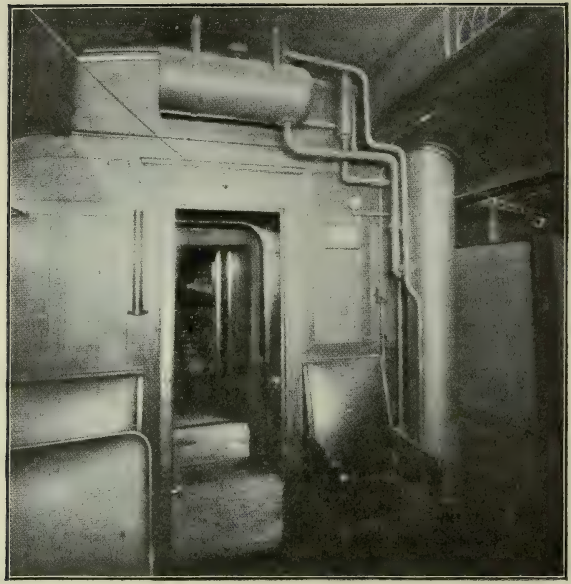


Fig. 4. — Acetylene car lighting on Great Northern Railway (United States). Interior of second-class coach.

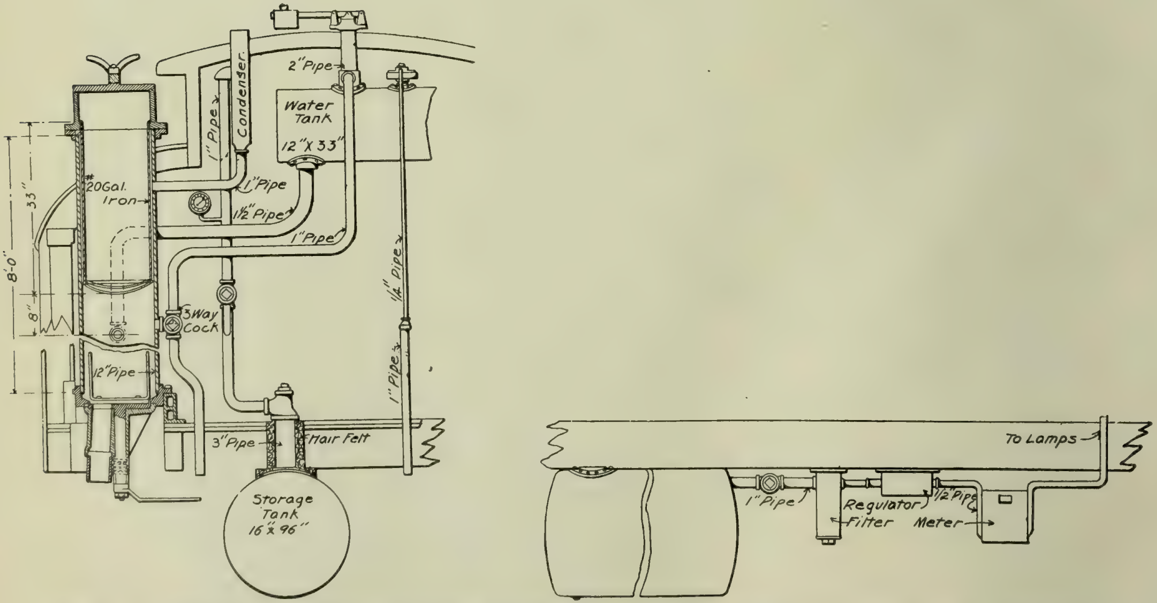


Fig. 5. — Acetylene car lighting on Great Northern Railway (United States). — Generator and accessories.

On December 14, 1905, sleeping car No. 956 went into service after having been equipped with this individual generator system. The car had 22 $^{3}/_{4}$-foot burners and 7 $^{1}/_{2}$-foot burners, giving a total consumption of 20 cubic feet of gas per hour with all burners lighted, and went into service on night trains between St. Paul and Winnipeg with 80 pounds of carbide in the generator and the porter instructed to burn all the lamps as long as possible. The lamps were lighted at 4 p. m. and burned until 11.30 p. m. when all but 12 were put out, these 12 burning until 8 p. m. On the return trip the same test was given. The regulator was set for 2 $^{1}/_{2}$ inches normal pressure at the lamps and the car while in this service made the round trip on 75 pounds of carbide. The pressure on the generator while working, was between 1 and 5 pounds, and after lights were extinguished, rose to 10 or 12 pounds. The generator after running five or six hours had not heated to any appreciable extent. After making a number of trips on this line, the car was then put in trans-continental service and ran all through the winter successfully.

To prevent freezing below the floor, the heater pipes on the car are connected to cored conduits through the base of the generator. After the winter's test, these generators were adopted as standard for the lighting of Great Northern cars, and have been applied to cars as they go through the shops.

In order to determine consumption of gas on coaches and the number of feet of gas produced by 1 pound of carbide a test was made on coach No. 219 running between St. Paul and Duluth. A charge of 100 pounds of carbide, was placed in the generators on April 18, 1906. Meter readings taken when the car reached St. Paul were noted as follows :

April 20	78·8 cubic feet.
— 22	157 — —
— 24	230 — —
April 26	305·7 cubic feet.
— 28	377.4 — —
— 30	466 — —

On April 30, the rest of the gas was run out, the meter registering after using up all the carbide 470 cubic feet. This record was kept at St. Paul, and train crews were not informed that a test was being made, so that the car was not favoured in any way as to consumption of gas. The result, 4·7 cubic feet of acetylene per pound of carbide, shows the generator to be highly efficient, the records of the company showing the yield with the compressor system used was 3·65 cubic feet per pound.

During the month of June, 1906, comparison was made between coach No. 219 equipped with individual generator and coach No. 176 on the same train having the compressed system, both cars being on night trains between St. Paul and Duluth. The cost for gas for the entire month on coach No. 219 was $9·29, while the cost for gas on coach No. 176 was $13·28.

The cool generation is considered to give this generator a decided advantage. The generator is provided with a safety valve which would not allow the building up of any high pressure in emergencies, and the arrangement which causes the water to recede when a pressure is built up which exceeds the weight of the column of water due to the height of the water supply, controls the ordinary pressure of gas in the system.

[313 : 625.14]

4. — Cross-ties used by railroads in the United States in 1905.

(*The Railway Age.*)

In Forest Service Circular No. 43, issued by the United States department of agriculture, H. M. Hale, forest assistant, gives interesting statistics concerning the number and origin of cross-ties used by the steam railroads in the United States. As to the production he says :

Value of ties purchased by steam railroads of the United States in 1905.

KIND OF WOOD.	Number.	Average cost per tie.	Total.
Oak	34,677,304	$0·55	$19,072,517·20
Pine.	18,351,037	0·42	7,707,435·54
Cedar	6,962,827	0·44	3,063,643·88
Chestnut	4,717,604	0·48	2,264,449·92
Red fir	3,633,276	0·33	1,198,981·08
Cypress	3,483,746	0·33	1,149,636·18
Tamarack	3,060,082	0·36	1,101,629·52
Hemlock	1,713,090	0·33	565,319·70
Redwood	590,852	0·20	118,170·40
Western larch	311,120	0·45	140,004·00
Spruce	148,168	0·35	51,858·80
Birch	35,500	0·40	14,200·00
Beech	34,227	0·40	13,690·80
Maple	25,500	0·40	10,200·00
Miscellaneous	236,894	0·48	113,709·12
Total. . .	77,981,227	...	36,585,446·14

The total number of ties reported is 77,981,227, switch ties being reduced to an equivalent number of cross-ties. Of the total number of ties purchased, 14,459,521, or approximately 18·5 per cent, were for use in the construction of new track, leaving 63,521,706 for renewals. It will be noted that this is less than the total announced in the preliminary statement made by the Forest Service under date of May 17, 1906. This is the result of a correction for duplication made in compiling the preliminary report. Assuming that the unreported 2·9 per cent of trackage required ties in the same proportion as the reported trackage, the total number of ties purchased by the steam railroads of the United States in 1905 was 81,562,150. Estimating 10 millions additional ties for the electric lines, the total number of ties purchased last year in the United States was, in round numbers, 91,500,000.

Ties purchased by steam railroads of the United States in 1905.

KIND OF WOOD.	HEWED.			SAWED.			TOTAL.	
	Number.	Per cent of all ties of kind.	Per cent of all hewed ties.	Number.	Per cent of all ties of kind.	Per cent of all sawed ties.	Number.	Per cent.
Oak	30,296.498	87·4	50·2	4,380,806	12·6	24·9	34,677,304	44·5
Pine	11,799,435	64·3	19·5	6,551,602	35·7	37·2	18,351,037	23·5
Cedar	4,842,651	69·6	8·0	2,120,176	30·4	12·6	6,962,827	8·9
Chestnut	3,252,046	68·9	5·4	1,465,558	31·1	8·3	4,717,604	6·1
Red fir	1,410,215	39·0	2·3	2,223,061	61·0	12·6	3,633,276	4·6
Cypress	3,095,760	88·9	5·1	387,986	11·1	2·2	3,483,746	4·5
Tamarack	3,049,972	99·7	5·1	10,110	0·3	(1)	3,060,082	4·0
Hemlock	1,599,283	93·4	2·6	113,807	6·6	0·6	1,713,090	2·2
Redwood	500,904	84·8	0·8	89,948	15·2	0·5	590,852	0·8
Western larch	247,425	77·9	0·4	63,695	22·1	0·3	311,120	0·4
Spruce	60,190	40·6	0·1	87,978	59·4	0·5	148,168	0·2
Birch	25,500	71·8	0·1	10,000	28·2	(1)	35,500	(1)
Beech	6,020	17·9	(1)	28,207	82·1	0·1	34,227	(1)
Maple	25,000	98·0	0·1	500	2·0	(1)	25,500	(1)
Miscellaneous	187,942	79·3	0·3	48,952	21·7	0·2	236,894	0·3
Total	60,398,841	(2)77·4	100·0	17,582,386	(2)22·6	100·0	77,981,227	100·0

(1) Less than one-tenth of 1 per cent. — (2) Per cent of all ties.

The accompanying tables show the value, average cost, kind of wood and source of supply, of the 78 millions ties used by railroads aggregating 293,937 miles, this being 97·1 per cent of the total trackage in the United States on January 1, 1905, as given by Poor's Manual.

The source of supply is classified by regions, as follows :

Southern	Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Texas, Indian Territory.
Central	Ohio, West Virginia, Kentucky, Tennessee, Indiana, Illinois, Missouri.
Lake	Michigan, Wisconsin, Minnesota.
North Atlantic	New England States, New York, Pennsylvania, New Jersey, Delaware, Maryland.
Pacific Coast	Washington, Oregon, California.
Rocky Mountain	Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico.

Source of supply of ties purchased by steam railroads of the United States in 1905.

KIND OF WOOD.	REGIONS.												Total — Hewed and sawed.
	SOUTHERN.		CENTRAL.		LAKE.		NORTH ATLANTIC.		PACIFIC.		ROCKY MOUNTAIN.		
	Hewed.	Sawed.	Hewed.	Sawed.	Hewed.	Sawed.	Hewed.	Sawed.	Hewed.	Sawed.	Hewed.	Sawed.	
Oak.	11,406,130	570,806	14,554,592	2,966,758	240,824	101.823	4,094,952	741,419	...	...	...	...	34,677,304
Pine	10,197,766	4,182,193	10,400	18,600	641,941	2,420	3,137	2,000	...	1,254,125	946,191	1,092,264	18,351,037
Cedar	...	700	...	...	4,400,305	1,744,937	412,505	323,176	29,841	25,163	...	26,200	6,962,827
Chestnut	114,192	9,145	155,632	22,608	...	...	2,982,222	1,433,805	...	...	...	...	4,717,604
Red fir.	...	...	...	...	...	...	...	...	216,696	2,190,581	1,193,519	32,840	3,633,276
Cypress	3,087,960	386,986	7,800	1,000	...	...	...	...	...	...	...	...	3,483,746
Tamarack.	...	...	...	...	3,026,193	6,491	23,779	3,619	...	...	...	...	3,060,082
Hemlock	...	...	...	...	1,556,421	44,278	42,862	69,529	...	...	...	...	1,713,090
Redwood	...	...	...	...	...	...	...	...	500,904	89,948	...	...	590,852
Western larch	...	...	...	...	...	...	...	...	22,730	...	224,695	63,695	311,120
Spruce.	...	...	...	...	...	...	...	...	...	...	60,190	87,978	148,168
Birch	25,000	...	500	...	...	...	...	10,000	...	...	...	...	35,500
Beech	2,500	...	2,000	1,500	...	2,000	1,520	24,707	...	...	...	...	34,227
Maple	25,000	...	...	500	...	...	...	...	...	...	...	...	25,500
Miscellaneous	15,237	3,460	15,781	11,199	40,935	5,519	115,989	18,774	...	10,000	...	...	236,894
Total. . .	24,873,785	5,153,290	14,746,705	3,022,165	9,906,619	1,907,468	7,676,966	2,627,029	770,171	3,569,817	2,424,595	1,302,617	...
Per cent of all ties purchased in region	82·8	17·2	83·1	16·9	83·9	16·1	74·5	25·5	17·7	82·3	65·0	35·0	...
Total of hewed and sawed .	30,027,075		17,768,870		11,814,087		10,303,995		4,339,988		3,727,212		77,981,227
Per cent	38·5		22·8		15·1		13·2		5·6		4·8		100·00

Concerning the preservation the circular says :

As a result of the realization that the supply of tie material was not limitless, and more especially when it was found that the durable white oak could no longer be secured in sufficient quantities to meet the demands for renewals and new track, an attempt was made to devise methods for increasing the length of service of the inferior woods. Tie plates were introduced with marked success in reducing the wear when used on soft woods. It was soon found, however, that the tie plate was not sufficient, since the wood decayed so rapidly that renewals in a short time were often necessary. To meet this problem, experiments in preservative treatment of ties were taken up by several railroad companies, some of them working in co-operation with the Forest Service, and it seems safe to predict that within a comparatively short period of time, more treated than untreated ties will be used. The statistics for 1905 show that 7,510,000 ties, or nearly 10 per cent of the total number purchased, were given a preservative treatment of some character. During 1905, at least ten railroad companies were operating their own plants for the preservation of their construction material, and several others are contemplating the installation of such plants. In addition to the roads which treat their own timber, many others have their timber treated at commercial treating plants.

[656 .281]

5. — The Atlantic City accident.

(*Railroad Gazette*, November 2, 1906.)

The disaster at Atlantic City, N. J., last Sunday may have to be classed with the small number of unexplainable railroad accidents, for the officers of the Pennsylvania Railroad declare that they have been unable to discover its cause, and the coroner and others who have tried to believe that they knew it have produced no coherent evidence to substantiate their opinions. The first right-hand rail on the draw span was found displaced after the accident, but the evidence seems more in favour of the theory that this was caused by the derailment than that the derailment was caused by it. The fact that the bridge was nearly new and yet had been in service several weeks, is in favour of the assumption that it was sound, and the assertion of the officers of the road that the structure was first class in design, material and workmanship, is buttressed by the known excellence of all new work of that kind done by the Pennsylvania Railroad. This disaster may arouse the prejudiced feeling that the electrical operation of steam railroads is a risky experiment, based on the idea that all untried things are necessarily dangerous. For this superficial view there is no ground whatever, though it is unhappily true, that had a hundred tons of engine and tender been in front of the train, it would have formed a barrier which might have broken the fall of the passenger cars and thereby protected the passengers. The line was straight, and there is no suggestion that the motorman was at fault. There was no fog or darkness to impair his view or his efficiency. It is just ten years and three months since the crossing collision at Atlantic City, which killed 47 persons and injured 50, but it is only two years and one month since we had in this country a railroad disaster equally appalling — the butting collision at Newmarket, Tenn., in September, 1904, when 63 were killed. In August, 1904, the flood disaster at Eden, Colo., killed 88.

(*Railroad Gazette*, November 9, 1906.)

The cause of the derailment on the drawbridge of the West Jersey & Seashore, at Atlantic City, N. J., October 28, when a train of three passenger cars tumbled off the right hand side of a deck drawbridge, causing the death of 56 persons (55 passengers and the motorman of the train), has been decided by the coroner's jury to be the misplacement of the rail, and the main paragraph of the verdict is given below.

The main facts, reported in the *Railroad Gazette* last week, are substantially as there given, except that the signals are electro-pneumatic, controlled from a mechanical interlocking machine, and that the bridge has no pneumatic apparatus. It is opened and closed by manual power, an attendant and an assistant being on duty day and night, though vessel movements through the draw are few and far between. The draw span is 110 ft. 4 in. long. The rails of the track are 33 feet long. At the ends, each rail rests on the draw for 30 feet and on the fixed span for 3 feet, and the end of the rail on the shore has a 45 degree miter joint. The end on the draw is fastened by the usual splice bars, and the end on the shore is lifted when the bridge is to be opened. Alongside the miter joint, outside of the rail, is a railshoe 5 feet long, to carry the wheels over the joint without jar. The shoe is supported in a heavy angle iron trough, which also forms a guide for the rail.

Entering the drawspan from the fixed span, the rail is found resting in a guide consisting of a bottom plate 16 inches wide supporting two longitudinal angles 3 $^1/_2$ × 3 $^1/_2$ inches, on each side of the rail, fitting closely against its base. The first guide (for the right hand or outside rail) is 1 ft. 9 $^3/_4$ in. long; then there is a space 9 inches long, then another guide 10 inches long; then a space of 3 ft. 6 in., then a guide 10 inches, then a space 3 feet, and finally a guide 12 ft. 4 in. long, this last one having at the outside of the rail a third angle with the horizontal member at the top and level with the top of the rail, to brace it against any outward thrust of the wheels. The guides are fastened to every tie, the ties being 16 inches apart, center to center.

This right hand rail, resting 3 feet on the fixed span, was found to have been pushed to the left (inward), as though a wheel or wheels had gone off the track to the right of it, and it was a little bent in the first 10 feet of its length; and yet the witnesses say that the first guide was not disturbed. The other guides, including the long one, were found so much broken that nothing could be learned from their appearance to afford any light as to the course of the wheels over them, or whether anything but the wheels came in contact with them. The few eye-witnesses agree that the leading car of the train was the first to go off the track. Its trucks are reported as having been found intact, but the cow-catcher is broken and a part of it is missing. The missing part is supposed to be in the bottom of the river. The car ran some 100 feet before it climbed the outside guard timber. This timber is 6 × 8 inches notched 1 $^1/_2$ inches over the ties and bolted to every third tie. There are no inside guard rails. The displaced rail was not distorted in its surface, nor were there any marks on either its upper or its lower surface.

The bridge lock is of the well-known type, in which the unlocking of the bridge and lifting of the track rails so that they will clear the guides on the fixed span are done simultaneously by means of a capstan, working through a worm gear and bell cranks. In locking, the turning of the capstan simultaneously pushes wedges between the bridge and the shore support, and lowers the rails into the shore guides. The capstan and cranks must complete their movement before the signal levers in the cabin (which is on the fixed span on the Atlantic City side of the draw), are released so as to permit the signalman to set the signals to permit a train to proceed.

The occurrence of a derailment like this will give rise to the query why the interlocking of the signals was not made to depend not only on the bridge being in place, but also on the rails being secure. To this the Pennsylvania officers, having tried both methods, reply that they have deliberately employed the watchman instead of adopting the additional mechanical complication. The chance of a watchman's introducing danger by making a wrong move, or by omitting any move, is believed to be less than the chance of a disarrangement of mechanical parts which shall escape detection and lead to the display of a false clear signal, as has been known to occur.

On Wednesday, November 7, the jury listened to the testimony of James M. Whitman, a mechanical engineer who was called in by the Coroner and who had examined the cars and bridge, and after deliberating several hours brought in a verdict finding that the derailment was caused by " the north west end of the south west rail on the draw of the bridge being out of its proper position, due, we believe, to the neglect or oversight of the man in charge of the draw. " The jury then " strongly recommends that the men employed to operate the drawbridge inspect both ends of the draw before the signal is given for trains to pass the opening ends of the draw. " Mr. Whitman testified that a mark which he had found on the motor box of the truck (whether the front or rear truck is not stated) was made by the end of the displaced rail, and that measurements made by him convinced him that there could be no mistake in this conclusion. Certain marks found on the cowcatcher also were made by the protruding rail, Mr. Whitman believes.

There was testimony that Bridge-tender Stewart had had an angry discussion with the captain of the vessel which had passed through the draw a short time before the accident, and the jurymen believe that this may have caused Stewart to be inattentive to his duty. The theory accepted by the jury, based on Mr. Whitman's testimony, appears to be that the rail projected upward far enough to strike the cowcatcher (normally 4 $^1/_2$ inches above the rail), and was by that blow further displaced so as to leave it in a position to strike the motor-box.

The Coroner's Jury is composed of State Senator Edward S. Lee, who was chairman of Committee on Railroads in the last New Jersey Legislature; Isaac Bacharach, Samuel P. Headley, William Ashmead, Charles Roesch, Jr., and David R. Barrett, City Assessor.

[385. (09.2]

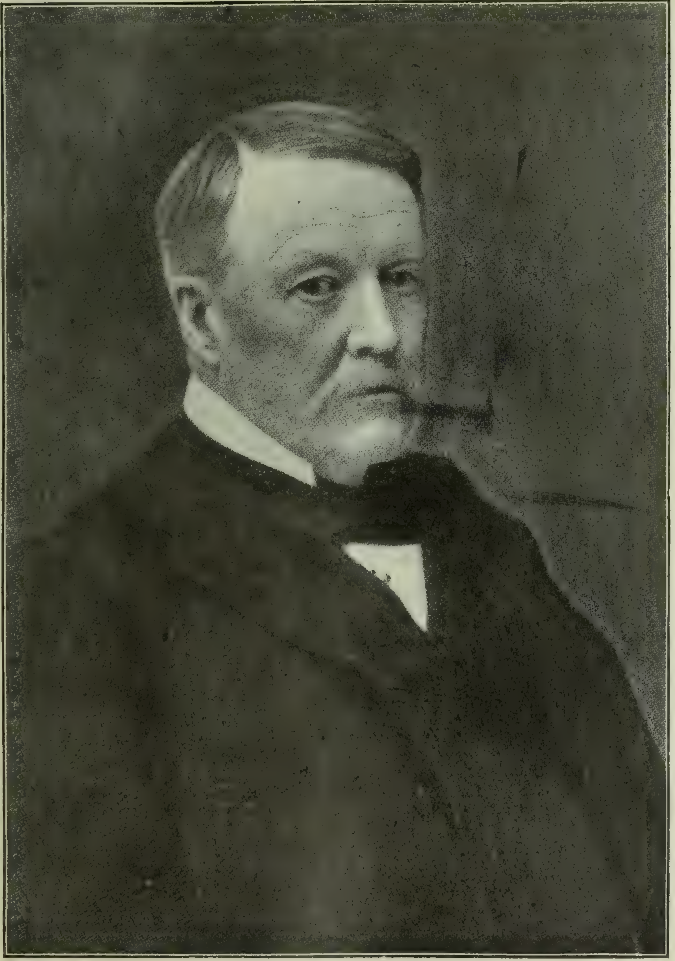
OBITUARY

Alexander Johnston CASSATT,

President of the Pennsylvania Railroad,
President honoraire of the seventh session of the International Railway Congress (Washington, 1905).

Alexander Johnston Cassatt, President of the Pennsylvania Railroad, died of heart disease at his town house in Philadelphia on December 28. Mr. Cassatt's health had been failing since last spring, and in June he went abroad to take a short vacation. His pleasure trip was cut short, however, by the investigation of the Interstate Commerce Commission into the relations between the officers of the Pennsylvania Railroad and the large mining and industrial companies along the company's lines. When the damaging testimony was made public Mr. Cassatt returned to his office at once, and with his accustomed vigor began a house-cleaning investigation of his own. Later in the summer he went to Bar Harbor, Me., and while there he contracted whooping cough from his grandchildren. His recovery left him weakened and unable to take up the work of his office, but on his return to Philadelphia he still kept in touch with the workings of the great railroad system of which he was the head through daily conferences with his subordinates at his house. He came to his office in Broad Street Station occasionally, the last time on December 8, and frequently drove out in his carriage. His death came suddenly and without pain while he was sleeping. He leaves a widow, two sons and a married daughter.

Mr. Cassatt was born in Pittsburg, December 8, 1839, his father, Robert S. Cassatt, having been the first Mayor of that city. His early youth was spent abroad, where he received his elementary education, and later attended the University of Darmstadt. The family returned to the United States and he entered Rensselaer Polytechnic Institute, graduating from there in 1859 as a civil engineer. He began his railroad career as an assistant engineer on the construction of a road in Georgia, but on the outbreak of the Civil War he went to the Pennsylvania as rodman. His ability brought him rapid promotion, and he was made successively assistant engineer of construction on the Connecting Railroad; in 1866, resident engineer on the Philadelphia & Erie; in 1867, superintendent of motive power of the same road, and in 1868, superintendent of motive power of the Pennsylvania Railroad. In 1874, he was made general manager of the lines east of Pittsburg and third vice-president of the Pennsylvania Railroad Company, and in 1880 was elected first vice-president. George B. Roberts was then president, and Mr. Cassatt was in line to succeed him. But when Mr. Roberts died in 1882, Frank Thomson was given the coveted office, and shortly after Mr. Cassatt resigned and severed his active official connection with the Pennsylvania. He still retained his place as director and served as chairman of the Committee on Roads. He was elected president of



Alexander Johnston Cassatt.

the New York, Philadelphia & Norfolk, one of the subsidiary companies of the Pennsylvania, in 1885, and held that office until his death. After he dropped active railroad work, Mr. Cassatt devoted himself to outside interests and amusements, principally horses, and for seventeen years he remained in retirement from business. When Mr. Thomson died in 1899, the board of directors unanimously elected Mr. Cassatt as president of the lines east and west of Pittsburg. At 60 years of age, his career was just beginning, but during the last seven years of his life he accomplished more, perhaps, than any other man of his time. Another three years would have seen the completion of the stupendous improvements in and around New York which he inaugurated. These will stand as a monument to his aggressive genius in the years to come.

In these days of "railroad kings," of Goulds, Harrimans, Vanderbilts and Rockefellers, most railroad officers are mere puppets. Mr Cassatt did not own the Pennsylvania Railroad or even a large part of it, but he owned the confidence of the stockholders, and it can be said that he never abused it. His word was final and his direction of the affairs of the company, financial, political and operative, was intimate and absolute. The expansion of the Pennsylvania during the last seven years was his work, his was the master mind directing, devising and always looking ahead with unlimited faith in the possibilities of the great transportation machine which he was creating and perfecting. He stands without a peer as a railroad man, not as a financier manipulating stocks and ownership, but as a navigator at the helm, running the railroad.

One of the first aggressive acts of Mr. Cassatt after being elected president was to begin a bitter fight between the Rockefeller, Carnegie and Gould interests over rates. He enlisted the New York Central, and together they established more profitable rates to the seaboard. In retaliation, Gould forced an entrance into Pittsburg, but paid for it by the ousting of the Western Union Telegraph Company from the Pennsylvania Lines. There was no parleying over the ejectment. Mr. Cassatt ordered the poles to be cut down over night, and the next day, before his opponents had a chance to resort to the courts and get out injunctions, the roadbed was strewn with tangled wires and broken poles.

Mr. Cassatt began his administration with the idea of making impregnable the position of the Pennsylvania Railroad. To do this required two things, expansion and improvement of the existing lines. The Pennsylvania acquired a controlling interest in the Baltimore & Ohio, its nearest competitor, and then successively a large interest in the Norfolk & Western and the Chesapeake & Ohio. The coal traffic was thus virtually controlled. The Long Island Railroad promised to prove useful in creating better terminals at New York; he bought that quietly before any definite plans had been made for its utilization. Meanwhile the vast scheme of improvements to existing lines was being worked out and begun. Philadelphia and Pittsburg, the two terminals of the main line across Pennsylvania, were attacked first. The network of tunnels, yards and overhead lines in Philadelphia was reconstructed, and the hills of Pittsburg cut away to make room for yards and a new passenger terminal. At Altoona and Harrisburg, the yards were doubled and trebled to make room for the cars that were to come. Hardly a mile of the main line was untouched in the betterment work, reducing grades, straightening out curves and putting in additional tracks. A new low grade freight line from Pittsburg to tidewater was built at enormous cost. It was Mr. Cassatt's ambition to see six tracks across the state, and for most of the distance now there are that number, all carrying traffic and all crowded. The financing of these improvements fell to him. That he managed always to get the money needed and never undermined the credit of the road is proof enough of his ability as a financier. In six years, the Pennsylvania has floated nearly $400,000,000 in new securities to pay for this programme of improvement.

The terminal improvements in New York, however, surpass any of the others. Mr. Cassatt began on the scheme in 1902. The North river bridge project, to which he was at one time attracted, having fallen through, he and his associates planned anew, with the result that in 1903 it was announced that the Pennsylvania would build tunnels under the two rivers and the island of Manhattan, and have a passenger terminal in the heart of the city. It was a daring undertaking, for its cost was estimated at over $75,000,000, and the return on the investment was to come solely from an undeveloped passenger traffic. A great freight yard was to be built in the upper bay, and the New York Connecting through Brooklyn and Queens and over a bridge across the East river at Ward's Island was to connect Long Island by rail with New England. It took all of Mr. Cassatt's persuasive powers to commit his directors to the scheme and to persuade bankers and financiers to advance the money for it. His death has come before he could see the realization of his plans, but he at least had the satisfaction of knowing that the necessary money was provided and that the work was well under way, and would go forward to the end as he had planned it.

Mr. Cassatt was a diffident man, painfully shy before an audience of any size, but at a directors' meeting or in conferences with his officers, speaking quickly to the point and as incisively as he thought. In his offices at Philadelphia he was impregnable, and it was easier to get an audience with a king than with him. His time was taken up with thinking, and acting, and he made the rule to see no one that he did not call in during business hours. He was fond of the good things of life and lived and worked among luxurious surroundings, which his large private fortune permitted him to enjoy. Horses were his recreation, and his racing stable was at one time well known. In later years, he took up the breeding of fancy coach horses and spent much of his time at his large stock farm near Berwyn.

The death of such a man — he can truthfully be called great — is a great loss to the Pennsylvania Railroad and to the railroad interests, no matter who his successor may be. He was an inspiring figure to his associates, a man with a moral calibre beyond criticism, who commanded the respect and esteem of all who knew him.

(Railroad Gazette.)

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[016 .385. (02]

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1906 **614** .8
Annales des ponts et chaussées, 3e trimestre, p. 192.

CARNOT (P). — Le coup de pression. (6,300 mots & fig.)

1906 **313** .385 (.469)
Annales des ponts et chaussées, septembre, p. 861.

Résultats généraux de l'exploitation des chemins de fer portugais en 1904 et 1903. (3 tableaux.)

1906 **313** .385 (.431)
Annales des ponts et chaussées, septembre, p. 863.

Résultats de l'exploitation du réseau des chemins de fer de l'État prussien pendant les exercices 1904 et 1903. (6 tableaux.)

1906 **313** .385 (.47)
Annales des ponts et chaussées, septembre, p. 866.

Résultats d'exploitation des chemins de fer d'intérêt général en Russie pendant les années 1903 et 1902. (5 tableaux.)

1906 **313** .385 (.494)
Annales des ponts et chaussées, septembre, p. 869.

Résultats de l'exploitation des chemins de fer suisses en 1904 et 1903. (5 tableaux.)

Annales des travaux publics de Belgique. (Bruxelles.)

1906 **624** .2 (01
Annales des travaux publics de Belgique, décembre, p. 1215.

IHRO. — La recherche du moment maximum dans une poutre simple sur deux appuis soumise à l'action d'une charge uniformément répartie et d'une série de charges concentrées formant convoi. (1,800 mots & fig.)

1906 **385** .1 (.73)
Annales des travaux publics de Belgique, décembre, p. 1235.

TILLIER (J.). — Les chemins de fer aux États-Unis. (8,400 mots & tableaux.)

Bulletin du Congrès international des chemins de fer. (Bruxelles.)

1906 **625** .143.3
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1413.

MOYLE (G.). — Rails ronflants : un phénomène mystérieux. (2,600 mots & fig.)

1906 **531** .87
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1420.

MINNE (André). — Note sur le desserrage des écrous. (1,400 mots & fig.)

1906 **625** .61 (.42)
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1424.

GLENDENNING (Seymour). — Le chemin de fer économique de Burton à Ashby. (2,600 mots & fig.)

1906 **656** .256.3 & **625** .4
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1431.

Signaux automatiques sur les chemins de fer souterrains de Londres. (8,600 mots & fig.)

1906 **385** .517
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1453.

Institutions de prévoyance (question XVI, 7ᵉ session). Discussion. (19,500 mots & 3 tableaux.)

1906 **385** .517
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1496.

RIEBENACK (M.). — Institutions de prévoyance (question XVI, 7ᵉ session). 2ᵉ supplément à l'exposé nº 1. Annexe à la discussion. (2,200 mots & 1 tableau.)

1906 **385** .517 (.942)
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1502.

PICKERING (John). — Institutions de prévoyance (question XVI, 7ᵉ session). Note sur les institutions de prévoyance des chemins de fer de l'État de l'Australie du Sud. Annexe à la discussion. (2,200 mots & 4 tableaux.)

1906 **625** .143.2
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1510.

Le phosphore dans les rails en acier. (1,300 mots.)

1906 **621** .131.2
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1512.

Limites des charges sur les essieux. (1,100 mots.)

1906 **625** .144.1
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1514.

Longueur maximum adoptée pour les rails de la voie courante par les grands réseaux français. (650 mots.)

1906 **54**
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 1515.

La controverse sur le radium. (2,600 mots.)

1906 **016** .385. (02
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 119.

Bibliographie mensuelle des chemins de fer. — Livres. (27 fiches.)

1906 **016** .385. (05
Bull. du Congrès des chemins de fer, nº 12, décembre, p. 122.

Bibliographie mensuelle des chemins de fer. — Périodiques. (181 fiches.)

Bulletin de la Société d'encouragement pour l'industrie nationale. (Paris.)

1906 **621** .33
Bull. de la Soc. d'enc. pour l'ind. nat., nº 9, novembre, p. 952.

RICHARD (G.). — La question des chemins de fer électriques. (3,000 mots.)

1906 **621** .133.2
Bull. de la Soc. d'enc. pour l'ind. nat., nº 9, novembre, p. 1010.

Les avaries des foyers des locomotives. (2,000 mots & fig.)

Bulletin de la Société des ingénieurs civils de France. (Paris.)

1906 **669**
Bulletin de la Soc. des ing. civ. de France, octobre, p. 570.

GUILLET (L.). — Traitement thermique des produits métallurgiques. (9,000 mots, tableaux & fig.)

Éclairage électrique. (Paris.)

1906 **625** .233
Éclairage électrique, nº 49, 8 décembre, p. 369.

VALBREUZE (R. de). — Nouveaux systèmes pour l'éclairage électrique des trains. (3,200 mots, tableaux & fig.)

Génie civil. (Paris.)

1906 **621** .116 & **621** .134.3
Génie civil, nº 1278, 8 décembre, p. 94.
— nº 1279, 15 — p. 110.

PIAUD (L.). — La surchauffe de la vapeur et sa distribution par soupapes équilibrées. (4,800 mots & fig.)

1906 **531**
Génie civil, n° 1278, 8 décembre, p. 96.

MOREL (M. A.). — L'autoloc. Système de blocage automatique et instantané. (2,200 mots & fig.)

1906 **625** .175
Génie civil, n° 1279, 15 décembre, p. 116.

Draisines légères à pétrole pour voie ferrée. (500 mots & fig.)

1906 **656** .211.5
Génie civil, n° 1280, 22 décembre, p. 127.

Ascenseurs électriques pour voyageurs du Baker Street and Waterloo Railway, à Londres. (1,500 mots & fig.)

1906 **656** .211.7
Génie civil, n° 1280, 22 décembre, p. 130.

Projet d'un service de ferry-boats entre la France et l'Angleterre. (1,000 mots & fig.)

Nouvelles annales de la construction. (Paris.)

1906 **624** .2 (01
Nouvelles annales de la construction, n° 624, décembre, p. 184.

COSYN (L.). — Étude pratique sur le glissement longitudinal des poutres métalliques à âme pleine. (3,000 mots, 4 tableaux & fig.)

Portefeuille économique des machines. (Paris.)

1906 **656** .237.2
Portefeuille économique des machines, n° 612, décembre, p. 177.

HERVIEU (J.). — Appareil imprimeur-distributeur-contrôleur de billets de chemins de fer. (5,500 mots & fig.)

Revue générale des chemins de fer et des tramways. (Paris.)

1906 **625** .215
Revue générale des chemins de fer, n° 6, décembre, p. 345.

CHABAL & BEAU. — Expériences faites en 1897 à la Compagnie Paris-Lyon-Méditerranée sur le déplacement transversal relatif des tampons voisins de deux véhicules consécutifs d'un train. (5,000 mots, 1 tableau & fig.)

1906 **725** .32
Revue générale des chemins de fer, n° 6, décembre, p. 367.

DUPUIS (D.). — Note sur la nouvelle halle des messageries de la compagnie du chemin de fer du Nord. (4,800 mots & fig.)

1906 **313** .385 (.73)
Revue générale des chemins de fer, n° 6, décembre, p. 379.

Statistique des chemins de fer des États-Unis pour l'exercice finissant le 30 juin 1904. (Tableaux.)

1906 **621** .33
Revue générale des chemins de fer, n° 6, décembre, p. 387.

Exposition de Milan. Traction électrique par courant monophasé. (800 mots & fig.)

1906 **656** .258
Revue générale des chemins de fer, n° 6, décembre, p. 389.

Exposition de Milan. Serrure électrique système Cornillon de la Compagnie d'Orléans. (1,000 mots & fig.)

1906 **621** .138.2
Revue générale des chemins de fer, n° 6, décembre, p. 392.

Installations mécaniques pour la manutention du combustible sur les chemins de fer allemands. (1,600 mots & fig.)

1906 **621** .131.3
Revue générale des chemins de fer, n° 6, décembre, p. 397.

Essais par la Compagnie d'Orléans, de locomotives à vapeur surchauffée. (1,200 mots, 1 tableau & fig.)

Revue de mécanique. (Paris.)

1906 **621** .9 (01
Revue de mécanique, n° 5, novembre, p. 431.

CODRON (C.). — Expériences sur le travail des machines-outils. (3,000 mots & fig.)

In German.

Annalen für Gewerbe und Bauwesen. (Berlin.)

1906 **621** .132.5
Annalen für Gewerbe und Bauw., N^{r} 707, 1. Dezember, p. 210.

SCHWARZE (B.). — $^{3}/_{4} + {}^{3}/_{4}$ gekuppelte Güterzuglokomotive der französischen Nordbahn. (1,300 Wörter & Fig.)

1906 **621** .132.3
Annalen für Gewerbe und Bauw., N^{r} 708, 15. Dezember, p. 221.

NAGEL (R.). — Neueste Schnellzugs-Lokomotivtype Kategorie I^{n} der königl. ungarischen Staatsbahnen (140 km. Stundengeschwindigkeit). (1,800 Wörter & Fig.)

1906 **625** .242
Annalen für Gewerbe und Bauw., N^{r} 708, 15. Dezember, p. 224.

Koppel-Selbstentlader D. R. P. (1,500 Wörter & Fig.)

1906 **625** .212

Annalen für Gewerbe und Bauw., Nr 708, 15. Dezember, p. 226.

HIPPEL. — Nahtlos gepresste Speichenräder für Eisenbahnfahrzeuge (System Ehrhardt), ihre Herstellung und ihre Eigenschaften im Vergleich zu gewalzten Scheibenrädern und geschweissten Speichenrädern. (3,200 Wörter, 2 Tabellen & Fig.)

Beton und Eisen. (Berlin.)

1906 **721** .9 (01

Beton und Eisen, Heft 12, p. 308.

MASEREEUW (H.). — Versuch mit einer Platte aus Betoneisen für einen Tunnel im Rangierbahnhofe der Holländischen Eisenbahn-Gesellschaft zu Watergraafsmeer bei Amsterdam. (1,500 Wörter, 3 Tabellen & Fig.)

1906 **721** .9

Beton und Eisen, Heft 12, p. 313.

HAIMOVICI (E.). — Zur Frage : Wie kann die Anwendung des Eisenbetons in der Eisenbahnverwaltung wesentlich gefördert werden? (1,100 Wörter, 1 Tabelle & Fig.)

1906 **624** .2 (01 & **721** .9 (01

Beton und Eisen, Heft 12, p. 315.

FRANK. — Der Einfluss veränderlichen Querschnitts auf die Biegungsmomente kontinuierlicher Träger, unter besonderer Berücksichtigung von Betoneisenkonstruktionen. (1,600 Wörter & fig.)

OEsterreichische Eisenbahn-Zeitung. (Wien.)

1906 **313** .385 (.43)

Œsterreichische Eisenbahn-Zeit., Nr 36, 10. Dezember, p. 337.

Statistische Nachrichten von den Eisenbahnen des Vereines Deutscher Eisenbahnverwaltungen für das Rechnungsjahr 1904. (1,800 Wörter.)

1906 **385** .15 (.436)

Œsterreichische Eisenbahn-Zeit., Nr 37, 17. Dezember, p. 345.

STRACH (H.). — Die Verstaatlichung der Kaiser Ferdinands-Nordbahn. (2,800 Wörter.)

1906 **385** .15 (.436) & **656** .237 (.436)

Œsterreichische Eisenbahn-Zeit., Nr 38, 24. Dezember, p. 357.

WEINBERG (E.). — Die Verstaatlichung der k. k. priv. Kaiser Ferdinands-Nordbahn und der Verrechnungsdienst der k. k. œsterr. Staatsbahnen. (1,400 Wörter.)

1906 **347** .234

Œsterreichische Eisenbahn-Zeit., Nr 39, 31. Dezember, p. 365.

KOWARZ (W.). — Die Zuständigkeit der Behörden zur Entschädigungsfeststellung für aufzulassende Bahnübersetzungen und die Berechnung dieser Entschädigung. (3,000 Wörter.)

Elektrische Bahnen und Betriebe. Zeitschrift für Verkehrs- und Transportwesen. (München.)

1906 **621** .33

Elektrische Bahnen u. Betriebe, Heft 35, 14. Dezember, p. 670.

ROSA (K.) & LIST (V.). — Der elektrische Betrieb der Wiener Stadtbahn. (1,300 Wörter & Fig.)

Organ für die Fortschritte des Eisenbahnwesens in technischer Beziehung. (Wiesbaden.)

1906 **621** .134.2

Organ für die Fortschritte des Eisenbahnw., 12. Heft, p. 239.

METZELTIN. — Neuere Lokomotivsteuerungen. (2,000 Wörter, 1 Tabelle & Fig.)

1906 **656** .21

Organ für die Fortschritte des Eisenbahnw., 12. Heft, p. 244.

BLUM (O.). — Die Bahnhofanlagen der Illinois-Zentral-Bahn in Neu-Orleans. (2,400 Wörter & Fig.)

1906 **656** .256

Organ für die Fortschritte des Eisenbahnw., 12. Heft, p. 247.

EDLER (R.). — Ueber einige Anordnungen der Blockwerke und Stellwerksteile zum Ersatze der Hebel- und Unterweg-Sperre bei den Stellhebeln der Ausfahrsignale in Stationen. (2,200 Wörter.)

1906 **624** .2 (01 & **721** .9 (01

Organ für die Fortschritte des Eisenbahnw., 12. Heft, p. 250.

BARKHAUSEN (G.). — Theorie der Verbundbauten in Eisenbeton und ihre Anwendung. (6,500 Wörter & Fig.)

1906 **313** .385 (.43)

Organ für die Fortschritte des Eisenbahnw., 12. Heft, p. 263.

Statistische Nachrichten von den Eisenbahnen des Vereines Deutscher Eisenbahn-Verwaltungen für das Rechnungsjahr 1904. (Tabellen.)

1906 **624** .63

Organ für die Fortschritte des Eisenbahnw., 12. Heft, p. 266.

Strassenbrücken aus Eisenbeton. Chicago, Indianapolis und St. Louis-Bahn. (350 Wörter & Fig.)

1906 **625** .143.4
Organ für die Fortschritte des Eisenbahnw., 12. Heft, p. 267.

SCHULER (J.).— Elastischer Keilstoss mit einem oder zwei Keilen. (700 Wörter & Fig.)

Schweizerische Bauzeitung. (Zürich.)

1906 **625** .258. (09
Schweizerische Bauzeitung, Nr 22, 1. Dezember, p. 260.
— — Nr 23, 8. — p. 273.

ABT (S.). — Beitrag zur Geschichte der Zangenbremsen. (4,500 Wörter & Fig.)

1906 **721** .9 (01
Schweizerische Bauzeitung, Nr 26, 29. Dezember, p. 309.

Untersuchungen von armiertem Beton auf reine Zugfestigkeit und auf Biegung unter Berücksichtigung der Vorgänge beim Entlasten. (2,300 Wörter & Fig.)

Zeitschrift für Architektur und Ingenieurwesen. (Wiesbaden.)

1906 **69** (01
Zeitschrift für Architektur und Ingenieurw., Heft 6, p. 494.

HERTWIG (A.). — Die Entwicklung einiger Prinzipien in der Statik der Baukonstruktion und die Vorlesungen über Statik der Baukonstruktion und Festigkeitslehre von G. C. Mehrtens. (8,000 Wörter & Fig.)

Zeitschrift für Kleinbahnen. (Berlin.)

1906 **621** .14
Zeitschrift für Kleinbahnen, Heft 12, Dezember, p. 791.

STOBRAWA. — Die elektrische gleislose Bahn Ahrweiler. (2,200 Wörter, 1 Tabelle & Fig.)

Zeitschrift des österreichischen Ingenieur- und Architekten-Vereines. (Wien.)

1906 **621** .13 (06.4 (.45)
Zeit. des öst. Ingen.- und Archit.-Ver., Nr 49, 7. Dezemb., p. 681.

SANZIN (R.). — Die Lokomotiven auf der Internationalen Ausstellung in Mailand 1906. (7,200 Wörter, 1 Tabelle & Fig.)

Zeitschrift des Vereines deutscher Ingenieure. (Berlin.)

1906 **621** .87
Zeit. des Vereines deutsch. Ingen., Nr 50, 15. Dezember, p. 2011.

JORDAN (F.).— Kritik der Bremssysteme bei elektrisch betriebenen Hebezeugen. (4,800 Wörter, 1 Tabelle & Fig.)

1906 **621** .13 (06.4
Zeit. des Vereines deutsch. Ingen., Nr 51, 22. Dezember, p. 2049.

METZELTIN. — Die Eisenbahnbetriebsmittel auf der Bayerischen Landesausstellung in Nürnberg 1906. (4,400 Wörter, 1 Tabelle & Fig.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1906 **625** .155
Zeitung des Vereins, Nr 92, 28. November, p. 1435.

ENGLER. — Güterverkehr über die russische Grenze und Umsetzwagen nach System Breidsprecher. (1,800 Wörter & Fig.)

1906 **621** .131.3
Zeitung des Vereins, Nr 93, 1. Dezember, p. 1455.

Versuchsergebnisse mit der $^3/_5$ gekuppelten Heissdampf-Schnellzuglokomotive der preussisch-hessischen Staatsbahnen (1,000 Wörter.)

1906 **656** .234
Zeitung des Vereins, Nr 94, 5. Dezember, p. 1467.

SCHÖNING (O.). — Vorschlag zu einem vereinfachten Gepäckabfertigungsverfahren. (1,200 Wörter & Tabellen.)

1906 **614** .8
Zeitung des Vereins, Nr 100, 29. Dezember, p. 1559.

Verbesserungen an Lokomotiven zur Förderung der Gesundheit und Leistungsfähigkeit des Personals. (1,800 Wörter.)

Zentralblatt der Bauverwaltung. (Berlin.)

1906 **725** .31
Zentralblatt der Bauverwaltung, Nr 99, 8. Dezember, p. 632.

RÜDELL. — Neuere Eisenbahnhochbauten. (1,100 Wörter & Fig.)

In English.

American Engineer and Railroad Journal. (New York.)

1906 **621** .7
American Engineer & R. Journal, No. 12, December, p. 451.

Betterment work on the Santa Fe. (15,000 words, tables & fig.)

Bulletin of the American Railway Engineering and Maintenance of Way Association. (Chicago.)

1906 **625** .14 (01
Bull. Amer. Ry. Eng. & Maint. of Way Ass., No. 80, Oct., p. 4.

SELBY (O. E.). — A study of the stresses existing in track superstucture and rational design based thereon. (3,000 words, 1 table & fig.)

1906 **624**. (01
Bull. Amer. Ry. Eng. & Maint. of Way Ass., No. 81, Nov., p. 5.

GUPPY (B. W.). — Maintenance of existing metal bridges. (3,000 words, tables & fig.)

1906 **625** .142.2
Bull. Amer. Ry. Eng. & Maint. of Way Ass., No.81, Nov., p.23.

CURTIS (W. W.). — Some notes on the preservation. (3,000 words.)

Bulletin of the International Railway Congress. (Brussels.)

1906 **385** .14 (.73)
Bulletin of the Railway Congress, No. 12, December, p. 1761.

McPHERSON (Logan G.). — Governmental regulation in the United States. (4,700 words.)

1906 **625** .216
Bulletin of the Railway Congress, No. 12, December, p. 1771.

DOYEN (J.). — Buffers during shunting operations and during the braking of long trains. (1,900 words & fig.)

1906 **621** .131.3
Bulletin of the Railway Congress, No. 12, December, p. 1779.

GOSS (Dr. W. F. M.). — Locomotive tests. (10,300 words, tables & fig.)

1906 **656** .254
Bulletin of the Railway Congress, No. 12, December, p. 1817.

BURDICK (H. L.) & SAUNDERS (W. T.). — The elephone in railroad service. (3,000 words.)

1906 **656** .237
Bulletin of the Railway Congress, No. 12, December, p. 1823.

Book-keeping (question XIV, 7th session). Discussion. (13,000 words.)

1906 **656** .237
Bulletin of the Railway Congress, No. 12, December, p. 1851.

RICHTER (J. DE). — Book-keeping (question XIV, 7th session). Letter concerning the conclusions of his eport. Appendix to the discussion. (1,550 words.)

1906 **385** .581
Bulletin of the Railway Congress, No. 12, December, p. 1855.

Duration and regulation of work (question XV, 7th session). Discussion. (6,500 words.)

1906 **625** .253
Bulletin of the Railway Congress, No. 12, December, p. 1871.

FARMER (C. C.). — Handling the air brake in passenger train service. (2,100 words.)

1906 **625** .253
Bulletin of the Railway Congress, No. 12, December, p. 1874.

Diagrams of K triples. (1,000 words & fig.)

1906 **625** .144.1
Bulletin of the Railway Congress, No. 12, December, p. 1878.

Maximum length of rails on the lines of the chief French railways. (750 words.)

1906 **621** .14 (09.3 (.42)
Bulletin of the Railway Congress, No. 12, December, p. 1879.

Road motor-car service. (1,500 words & fig.)

1906 **016** .385. (02
Bulletin of the Railway Congress, No. 12, December, p. 119.

Monthly bibliography of railways. — Books. (27 labels.)

1906 **016** .385. (05
Bulletin of the Railway Congress, No. 12, December, p. 122.

Monthly bibliography of railways. — Periodicals. (181 labels.)

Engineer. (London.)

1906 **621** .132.3
Engineer, No. 2657, November 30, p. 542.

Prairie type compound engines at Milan exhibition. (900 words & fig.)

1906 **621** .14
Engineer, No. 2657, November 30, p. 559.

CLARKSON (T.). — Steam as motive power for public service vehicles. (2,000 words & fig.)

1906 **656** .257
Engineer, No. 2658, December 7, p. 574.

Signalling at Newcastle-on-Tyne. (3,000 words & fig.)

1906 **621** .33 & **625** .4
Engineer, No. 2659, December 14, p. 598.

Great Northern, Piccadilly and Brompton Railway. (2,200 words & fig.)

1906 **621** .134.2
Engineer, No. 2660, December 21, p. 620

The Walschaerts valve gear. (2,500 words & fig.)

1906 **621** .132.3
Engineer, No. 2661, December 28, p. 651.

Six-coupled bogie passenger engine-Caledonian Ry. (400 words & fig.)

1906 **621** .94
Engineer, No. 2661, December 28, p. 661.

Driving-wheel tire lathe. (1,200 words, 1 table & fig.)

Engineering. (London.)

1906 **621** .132.3
Engineering, No. 2135, November 30, p. 720.

Four-cylinder compound locomotive with Lentz valves. (1,000 words & fig.)

1906 **621** .132.3
Engineering, No. 2135, November 30, p. 739.

Six-coupled passenger locomotive for the Caledonian Railway. (450 words & fig.)

1906 **656** .211.7
Engineering, No. 2136, December 7, p. 757.

The proposed channel ferry service. (2,200 words & fig.)

1906 **625** .253
Engineering, No. 2136, December 7, p. 761.

New Westinghouse Quick-acting brake. (2,100 words & fig.)

1906 **625** .214
Engineering, No. 2137, December 14, p. 787.

BAMBER (H. K.). — Axle bearings for heavy tonnage wagons; Indian railways. (1,000 words, 3 tables & fig.)

1906 **621** .132.8
Engineering, No. 2137, December 14, p. 793.

5-ton steam wagon. (2,400 words & fig.)

1906 **621** .132.3
Engineering, No. 2137, December 14, p. 798.

Four-cylinder compound locomotive; Austrian State Railways. (1,000 words & fig.)

1906 **625** .253
Engineering, No. 2139, December 28, p. 863.

The Chapsal-Saillot compressed-air brake. (1,300 words & fig.)

Engineering Magazine. (London.)

1906 **385**. (07.13
Engineering Magazine, December, p. 321.

BECKER (O. M.). — Modern adaptations of the apprenticeship system. (1,300 words, 1 table & fig.)

1906 **621** .7
Engineering Magazine, December, p. 339.

JACOBS (H. W.). — Organization and economy in the railway machine shop. (2,800 words & fig.)

Engineering News. (New York.)

1906 **621** .133.3
Engineering News, No. 21, November 22, p. 531.

Locomotive boilers with combustion chambers. (3,000 words & fig.)

1906 **656** .28 (01
Engineering News, No. 21, November 22, p. 536.

A Board of Trade report on an English railway accident : brakes for electric cars on steep grades. (5,500 words.)

1906 **625** .13
Engineering News, No. 23, December 6, p. 586.

Tunnel lining work in the Far West. (1,200 words & fig.)

1906 **625** .13
Engineering News, No. 24, December 13, p. 603.

FORGIE (J.). — The construction of the Pennsylvania R. R. tunnels under the Hudson River at New York city. (8,000 words, 2 tables & fig.)

1906 **721** .9 (01
Engineering News, No. 25, December 20, p. 643.

DOUGLAS (W. J.). — Practical hints for concrete constructors. (11,000 words & fig.)

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OUTERBRIDGE (A. E.). — Recent progress in metallurgy. (8,500 words & fig.)

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VAN ORNUM (J. L.). — The fatigue of concrete. (8,400 words, tables & fig.)

1906 **621** .13 & **621** .33
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SPRAGUE (F. J.). — Steam locomotive and electric operation for trunk-line traffic. A comparison of costs and earnings. (3,000 words.)

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1905/1906 **62**. (01
Proceedings of the Inst. of Civil Eng., vol. CLXVI, p^t IV, p. 78.

STANTON (T. E.) & BAIRSTOW (L.). — On the resistance of iron and steel to reversals of direct stress. (20,000 words, tables & fig.)

Railroad Gazette. (New York.)

1906 **656** .261 (.42)
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The British system of cartage and delivery of freight at terminals. (1,500 words & fig.)

1906 **625** .112 (.54)
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— No. 22, — 30, p. 482.

The railroad gages of India. (3,600 words, 5 tables & fig.)

1906 **625** .14 (01
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Best method of maintaining track for the tonnage and speed of to-day. (2,300 words.)

1906 **621** .138.5
Railroad Gazette, No. 21, November 23, p. 461.

EMERSON (H.). — Finished repair parts for locomotives. (1,600 words.)

1906 **621** .13 & **621** .33
Railroad Gazette, No. 21, November 23, p. 464.

MAYER (J.). — Steam versus electric operation of trunk lines. (4,200 words.)

1906 **625** .143.2
Railroad Gazette, No. 21, November 23, p. 467.

JOB (J.). — Steel rails. (2,200 words.)

1906 **621** .13 & **621** .33
Railroad Gazette, No. 22, November 30, p. 487.

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1906 **621** .134.3
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GOSS (W. F. M.). — High steam pressures in locomotive service. (2,700 words & fig.)

1906 **385**. (09.2
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McPHERSON (L. G.). — Samuel Spencer. (2,200 words & portrait.)

1906 **385** .1 (.73)
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The relationship of the railroads to the people. (2,600 words.)

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Repairs to steel freight cars. (1,400 words & fig.)

1906 **621** .132.3
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Four-cylinder compound express locomotive for the Danish State Railways. (1,500 words & fig.)

1906 **625** .242
Railroad Gazette, No. 25, December 21, p. 554.

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1906 **625** .122
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SESSER (J. C.). — Cost of steam shovel work. (2,000 words.)

Railway Age. (Chicago.)

1906 **385** .1 (.73)
Railway Age, No. 1589, November 23, p. 641.

SPENCER (S.). — Relationship of the railroads to the people. (1,700 words.)

1906 **656** .256
Railway Age, No. 1589, November 23, p. 646.

Automatic electric block signaling — Electrified lines Long Island Railroad. (1,000 words & fig.)

1906 **621** .134.3
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GOSS (W. F. M.). — High steam pressure in locomotive service. (3,300 words & fig.)

1906 **621** .132.4
Railway Age, No. 1590, November 30, p. 682.

Balanced compound Prairie type locomotive for the Atchison, Topeka & Santa Fe. (400 words & fig.)

1906 **725** .31
Railway Age, No. 1592, December 14, p. 746.

Proposed down-town terminal of the Hudson River tunnel system. (800 words & fig.)

1906 **625** .143.5
Railway Age, No. 1592, December 14, p. 751.

WEBBER (R. J.): — Holding power of railroad spikes. (4,000 words, 6 tables & fig.)

1906 **313 : 656** .28 (.73)
Railway Age, No. 1593, December 21, p. 779.

Accident record for the year ended June 30, 1906. (500 words & 4 tables.)

1906 **625** .216
Railway Age, No. 1593, December 21, p. 780.

New bumping posts for the Lackawanna. (800 words & fig.)

1906 **625** .246
Railway Age, No. 1593, December 21, p. 783.

MAC ENULTY (J. F.). — Repairs to steel freight cars and development of steel passenger cars. (3,300 words & fig.)

Railway Engineer. (London.)

1906 **656** .257
Railway Engineer, No. 323, December, p. 375.

Union switch & signal Co.'s all electric power plant. (1,200 words & fig.)

1906 **621** .132.6
Railway Engineer, No. 323, December, p. 383.

Six-wheels-coupled radial tank-engines; Japanese State Railways. (700 words & fig.)

Railway and Engineering Review. (Chicago.)

1906 **621** .134.3
Railway and Engineering Review, No. 47, November 24, p. 908.

High steam pressures in locomotive service. (1,700 words, 1 table & fig.)

1906 **656** .223.2
Railway and Engineering Review, No. 47, November 24, p. 919.

Car clearing houses, car pools, etc. (5,500 words.)

1906 **621** .132.8
Railway and Engineering Review, No. 48, December 1, p. 937.

Steam plant of the White motor car. (1,500 words & fig.)

1906 **656** .256.3
Railway and Engineering Review, No. 50, December 15, p. 970.

Automatic block signals with storage batteries, L. S. & M. S. Ry. (900 words & fig.)

1906 **625** .142.3
Railway and Engineering Review, No. 50, December 15, p. 979.

Steel ties. (1,300 words & fig.)

1906 **621** .338
Railway and Engineering Review, No. 51, December 22, p. 990.

Electric car equipment of the West Jersey & Seashore Line P. R. R. (2,000 words & fig.)

1906 **625** .13
Railway and Engineering Review, No. 51, December 22, p. 993.

Ventilation of tunnels. (9,000 words, 4 tables & fig.)

Railway Gazette. (London.)

1906 **656** .253
Railway Gazette, No. 22, November 30, p. 579.

EBOR. — Distant signals. (1.800 words.)

1906 **621** .13 & **621** .33
Railway Gazette, No. 22, November 30, p. 582.

MAYER (J.). — Steam locomotive and electric locomotive power. (3,000 words.)

1906 **621** .132.8
Railway Gazette, No. 22, November 30, p. 585.

Union Pacific motor car No. 8. (150 words & fig.)

1906 **656** .223.2
Railway Gazette, No. 23, December 7, p. 607.

WEST (F. W.). — Transhipping goods on railways. (3,200 words.)

1906 **621** .13 & **621** .33
Railway Gazette, No. 23, December 7, p. 612.

MAYER (J.). — Steam versus electric operation of trunk lines. (4,200 words.)

1906 **625** .143.2
Railway Gazette, No. 23, December 7, p. 615.

JOB (R.). — Steel rails. (2,200 words.)

1906 **625** .254
Railway Gazette, No. 24, December 14, p. 624.

Reliability of brake check-valves. (1,300 words & fig.)

1906 **621** .33 & **625** .4
Railway Gazette, No. 24, December 14, p. 629.

The Great Northern, Piccadilly & Brompton Railway. (3,000 words & fig.)

1906 **621** .13 & **621** .33
Railway Gazette, No. 24, December 14, p. 635.

Steam versus electric operation of trunk lines. (3,600 words.)

1906 **621** .134.3
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GOSS (W. F. M.). — High steam pressures in locomotive service. (2,700 words & fig.)

1906 **385** .1 (.73)
Railway Gazette, No. 25, December 21, p. 659.

The relationship of the railroads to the people. (2,600 words.)

1906 **625** .26
Railway Gazette, No. 25, December 21, p. 661.

Repairs to steel freight cars. (1,400 words & fig.)

1906 **621** .132.3
Railway Gazette, No. 26, December 28, p. 681.

Four-cylinder compound express locomotive for the Danish State Railways. (1,700 words & fig.)

Railway Magazine. (London.)

1906 **621** .33 (.42)
Railway Magazine, No. 114, December, p. 481.

ARTHURTON (A. W.). — The electrification of the Hammersmith and City (Joint Great Western and Metro politan) Railway. (3,400 words & fig.)

1906 **621** .132.1 (.42) & **656** .222.1 (.42)
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ROUS-MARTEN (C.). — British locomotive practice and performance. (3,800 words & fig.)

Railway Times. (London.

1906 **625** .61 (09.1 (.54)
Railway Times, No. 25, December 22, p. 633.

The Barsi light railway. (1,800 words & fig.)

1906 **656** .253
Railway Times, No. 26, December 29, p. 658.

Mechanical fog-signalling. (1,200 words & fig.)

Street Railway Journal. (New York.)

1906 **625** .143.2
Street Railway Journal, No. 21, November 24, p. 1012.

JOB (R.). — Steel rails. (1,300 words & fig.)

1906 **621** .33 (01
Street Railway Journal, No. 22, December 1, p. 1049.

ASHE (S. W.). — How to analyze train tests. (1,500 words, 1 table & fig.)

1906 **621** .335. (01
Street Railway Journal, No. 23, December 8, p. 1086.

Tests of the Ward-Leonard-Oerlikon electric locomotive. (1,300 words & fig.)

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HOLMAN (G. U. G.). — The financial promotion of electric railways. (6,000 words.)

Tramway & Railway World. (London.)

1906 **621** .33 & **625** .4
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Great Northern, Piccadilly, and Brompton Railway. London's longest tube. (6,500 words & fig.)

1906 **621** .33 (09.1 (.42)
Tramway & Railway World, December, p. 535.

Leyton district council tramways. (4,500 words & fig.)

In Italian.

Bollettino della Societá degli ingegneri e degli architetti italiani. (Roma.)

1906 **385** .1 (.45)
Bollet. del. Soc. degli ing. ed. arch. it., nº 47/48, 2 dic., p. 685.

La difficile situazione dell' azienda ferroviaria dello Stato. (10,500 parole.)

Giornale del genio civile. (Roma.)

1906 **62**. (01 (06.3
Giornale del genio civile, ottobre, p. 554.

Congresso dell' Associazione internazionale per la prova dei materiali. (11,000 parole.)

1906 **625 .13**
Giornale del genio civile, novembre, p. 597.

Il progetto d'una galleria sotto la Manica. (4,400 parole & fig.)

Ingegneria ferroviaria. (Roma.)

1906 **625 .1**
Ingegneria ferroviaria, nº 23, 1º dicembre, p. 373.
— — nº 24, 16 — p. 394.

Pro spluga. (8,200 parole, 1 tavole & fig.)

1906 **621 .13** (06.4
Ingegneria ferroviaria, nº 24, 16 dicembre, p. 398.

VALENZIANI (I.). — L'esposizione di Milano. Locomotive estere. (1,000 parole, 1 tavole & fig).

1906 **625 .23** (06.4
Ingegneria ferroviaria, nº 24, 16 dicembre, p. 402.

CERRETI (U.). — Vetture postali. (500 parole & fig.)

In Spanish.

Revista de obras públicas. (Madrid.)

1906 **624.** (01
Revista de obras públicas, nº 1631, 27 de diciembre, p. 625.

LAFARGA (P.). — Lanzamiento de puentes metalicos. (4,400 palabras & fig.)

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BULLETIN
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(ENGLISH EDITION)

[656 .223.2]

THE INTERCHANGE USE OF FREIGHT CARS IN NORTH AMERICA,

By W. F. ALLEN,
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The interchange of freight cars among the numerous railways of the United States, Canada and Mexico, is a business of great moment, and its regulations have of recent years become of more and more interest to American railway managers. A large proportion of the freight traffic is transported long distances without break of bulk, and the car in which the lading is first placed, consequently often passes over many different systems of railroads in proceeding from its point of shipment to its destination.

For many years, in fact from the beginning of through traffic up to July, 1902, the owner of the car was entitled to receive from the company using it, a certain rate per mile for each mile it was moved whether loaded or empty. This charge by mutual consent, but without any binding agreement, was established at three-quarters of a cent per mile. At that rate, it remained for a number of years until October, 1894, when it was reduced to six-tenths of a cent per mile. Higher rates were paid for certain classes of special cars, but the great bulk of the freight car equipment of the country was moved at this mileage rate. In 1894, the total number of freight cars belonging to railway companies, members of the American Railway Association was reported as about 1 million, and the movements of all were then paid for at the rate named.

One peculiarity of this system was that the accounts were kept by the user of the car, and that it was very difficult for the owner to verify the statements. In fact it was practically impossible to do so for the greater part of the cars in use. The figures were compiled primarily from the reports of the conductors of the freight trains and these were in the keeping of the users of the car. This placed a temptation in the way of the officials of impecunious roads, and it was sometimes charged that false statements of the mileage were made to the detriment of the interest of the owner of the car. Another disadvantage arose from the fact that no compensation was paid tor the use of the car while it remained upon sidings awaiting loading or unloading, a period which often covered many days.

It was generally considered at that time, that where reports were honestly made, the accounts pretty well balanced each other in the long run, and proposed changes in the system of interchange charges received but little attention from the higher grade of railway officials.

In 1888 however, an attempt was made to introduce a reform method of accounting by using what was called a " mixed per diem rate ". The principle upon which this plan was based, was that the owner of the car was entitled to receive a certain amount for each day it was in use, to cover the interest on its cost and the depreciation, and to an additional mileage rate to compensate for the ordinary wear and tear caused by its movements on the rails. The attempt of 1888 failed, however, because as it was claimed by its advocates, the agreement for its use did not include a sufficient number of roads, and because it was not continued sufficiently long to thoroughly test its advantages.

In 1893, the mixed system was again reported upon favourably by a committee of the American Railway Association, but it was never generally adopted. The rate then recommended was one half a cent a mile and 6 cents per day. In the course of the investigations made by this committee, it was developed that the average daily movement of a freight car was less than 25 miles.

The principal cause of the small daily movement of freight cars, is their detention at loading and unloading points. In order to remedy this evil, " car service associations " were formed at many of the larger terminals, and a demurrage of 1 dollar per day was exacted from the consignee of the car for any detention in excess of an agreed time, generally forty-eight hours. The business of these associations is in charge of a manager, and his supervision, in many cases, includes not only the terminal city, but also other points in the adjacent territory. Provision is made to relieve the consignee of this charge, where the circumstances warrant it. These associations are, for the most part, self supporting, and their operations serve to considerably relieve the congestion of cars at terminals and to release them for further service. Uniform general rules to govern these associations were adopted by the American Railway Association in October, 1889. Each has its own local rules.

The miles operated by the members of the American Railway Association increased from 145,869 in 1894 to 228,608 in 1906, and the cars owned from about 1 million to over 2 millions.

With this increased number of miles of road and in cars owned, the interchange car service has correspondingly increased and become much more important. It had been often urged that the true method of settling for interchange car service was upon the basis of a daily charge, or as it was technically called " straight per diem ". Many arguments were used against the adoption of this method of accounting although it possessed the obvious advantage of enabling the owner of the car to verify the statements and so to collect all that was due him. It was feared that the payments would become unduly burdensome to terminal lines, that the storing of cars in anticipation of traffic, a custom long in vogue, would become impracticable, and the profits of transportation frequently wiped out by the accumulated per diem charges.

In 1895, the question of the adoption of a per diem rate of 15 cents a day, was submitted by letter ballot to the members of the American Railway Association. It was favoured by 77 roads owning 490,271 cars and opposed by 77 roads owning 394,669; the owners of 235,000 cars did not vote. As by the terms of the vote it required the assent of the owners of 840,000 cars to adopt the proposition, it was declared lost.

In April 1902, the Committee on Car Service of the American Railway Association again reported in favour of the adoption of a " straight per diem ", this time at the rate of 20 cents per day. It accompanied its report with a carefully compiled set of rules to govern the interchange service, which rules provided for a " reclaim " of the amounts of per diem paid under certain conditions similar to those above mentioned. It provided also for an arbitration committee to settle all disputes that might arise under the operation of these rules.

When the report was being formulated by the Committee, two rates of per diem charges were considered, 15 and 20 cents. Twenty five miles per day at six-tenths of a cent per mile is the exact equivalent of 15 cents per diem, and that seemed to be the logical rate, since an increase in the charge was not the object sought. It was thought, however, that the new system would result in an increased movement and the rate recommended was fixed at 20 cents per day.

The report of the Committee was presented at the meeting of the American Railway Association held April, 1902, and its adoption was vigorously fought by the representatives of those companies who believed that the expenses of their lines would thereby be largely increased. The Association voted to recommend the adoption of the per diem rate and the accompanying rules, but left the final decision to a vote by letter ballot with the rather rigorous provision that it should not be adopted unless favoured by a majority of the members of the Association owning or controlling two thirds of all the freight cars owned by the entire membership. This provision, it was thought by some, would prevent the success of the movement, but on May 27, 1902, the Secretary was able to announce, that the required assents had been filed. The new Per Diem Rates under the terms of the resolution, therefore, took effect July 1, 1902.

In order to put the new rates into practical effect, a formal agreement was entered into between the roads concerned as follows :

The subscribing railroad company promises and agrees with each railroad company severally which subscribes and files a counterpart hereof with the Secretary of The American Railway

Association, that the subscriber will abide by the rules governing settlement for the use of freight cars, adopted by the Association and designated " Per Diem Rules " on the minutes of its proceedings; this agreement to continue for one year beginning July 1, 1902, and thereafter until withdrawn on or after July 1, 1903, by three months' previous notice in writing to the Secretary of the Association.

This agreement called the " Per Diem Rules Agreement " was signed by 93 per cent of the members of the Association representing 99 $^7/_{10}$ per cent of the cars owned.

As the first apparent result from the new regulation was an increase of one third in the cost of the use of " foreign " cars, an expense regarded by many as already large, orders were given in all parts of the country to send such cars to their " home roads "; that is to the road that owned them. These orders were generally obeyed, and cars came pouring in upon their own rails at a remarkable rate, as one high official stated " like rats out of their holes ". It is safe to say, that at no time in the history of American railways have the several companies had as many of their own cars upon their own rails as on July 1, 1902.

One special provision of the Per Diem Rules, was that a road had the right to demand the return of its car after it had been on another road for a period of twenty days. Upon making such a demand upon a specified form called a " penalty notice " it could exact a " penalty rate " of 1 dollar a day if the car had not been returned in ten days thereafter; that is within thirty days in all. It had frequently been the case that cars were away from their home roads for months at a time, and this penalty clause was provided with a view to securing their prompt return.

Owing to the contingencies of traffic, it was felt that the penalty rate could be collected only when cars had been held continuously by one road, and that on the transfer of the car in the ordinary routine of business to another road, a new term of use would commence at the per diem rate of 20 cents a day.

It was soon seen that by the temporary transfer of a car to an independent branch, or connecting line, the continuity of the term of service would be broken; in other words, to use the technical term, this action would " break penalty. " It was feared that some officials, who were in a position to do so, would be tempted to report upon paper the transfer of the car for the purpose of " breaking penalty " and so avoid the payment of the dollar rate, when the car itself had not been physically moved. Whether this action actually occurred or not, many believed it did, and in the absence of a direct charge, it was difficult to disprove. It was certain, however, that a large number of small independent branch roads sought to be admitted to the per diem rules agreement, and that their admission was generally favoured by the larger lines with which they connected. This naturally gave rise to the suspicion that they were being used as places of temporary refuge for cars, that otherwise would have had to pay the penalty rate.

When the subject of the adoption of a mixed per diem rate was first agitated, there were many freight cars in service having a capacity of only 30,000 lb. burden. Since then, they have been rapidly replaced by larger or stronger cars, so that the average car to-day is of about 60,000 lb. burden, with many cars in service of 80,000 and 100,000 lb. burden.

The average value of the freight cars in service, was estimated in the committee's report in 1901 as about 500 dollars basing their estimate upon reports received from a number of the principal lines. With their enlargement in size and the increase cost of manufacturing, owing to the rise in the price of labor and material, the cost of the cars of higher capacity ranges to-day from 1,000 to 1,300 dollars. An amount, therefore, which would compensate the owner for the use of a small car, was felt to be inadequated by the owners of these larger cars. Evidently this fact was as fully appreciated by the users of the cars as by the owners. It was recently stated, that a certain great railway company had added last year to its equipment 12,000 new large capacity cars. These cars had all been shipped loaded off the company's lines, and 90 per cent of them had never returned; so that when the statement was made, in spite of the large increase in its equipment, the company actually had upon its own lines less cars than a year ago. For the use, wear and tear, and interest on the cost of these cars 20 cents a day was not an adequate compensation.

It has been estimated that the average annual cost of keeping of a freight car in repair is not less than 60 dollars that an allowance of 5 per cent per annum for deterioration is not too much. For a car costing 1,000 dollars, these items would amount to 110 dollars per annum, while the maximum return at 20 cents per day was but 73 dollars per annum. The penalty rate in actual practice added about 2 $^1/_2$ cents per day to the average, making the total return 82·13 dollars per annum against a cost of 110 dollars per annum to the owner, without reckoning loss of interest on the investment.

Again, the owner naturally wished to retain the use of his car on his own lines, since with the enormous increase of transportation business on this continent during the past few years, traffic would sometimes be lost to the owner because there was not a sufficient number of cars on hand to handle it.

The first action taken to remedy this condition, was an increase in the per diem rate from 20 to 25 cents a day which took effect on July 1, 1906, the penalty rate of 1 dollar per day not being changed. Later in the present year, the active managers of a number of the roads, while finding themselves with an insufficient supply of cars, hesitated to recommend to their financial managers the purchase of additional equipment, since their previous action of this kind had only resulted in giving other roads the benefit of the use of the cars, at a rate of charge that did not compensate the owner for the investment.

The Committee on Car Service of the American Railway Association accordingly agreed to recommend that the per diem rate should be raised to 35 cents a day, without change in the penalty rate per day; that is, the penalty rate was to be 65 cents per day making 1 dollar per day in all.

Just previous to the meeting of the American Railway Association in October, 1906, the managing officials of a number of companies owing nearly one half the present car equipment of the country, held a consultation and decided that a radical change in the rate was necessary. Acting upon their suggestion, the proposal for the 35 cent rate was withdrawn, and in place of it, the question of the adoption of a rate of either 50 cents, or 75 cents, per day was substituted. This is to be submitted to a vote of the roads by letter ballot to take effect, if adopted, July 1, 1907. In either case, if adopted, the additional penalty rate is to be entirely abolished.

In the very early phases of this interchange business, a car would be shipped loaded from one road to a point on a connecting road and then be promptly reshipped to the owner either loaded or unloaded. When this practice prevailed on both roads the charges for cars were quite well equalized, and the rate being reciprocal was of little moment. As the demands of traffic increased, the return of a car empty to its owner, when a load was waiting for shipment in an opposite direction, was seen to be an economic loss, and it soon became a common practice, under such conditions, for the waiting load to be placed in whatever car was available without regard to ownership. Since the owner of the car did not participate in this traffic by receiving any share of the receipts from freight earnings, the reciprocal character of the business was entirely lost.

This use of a freight car, under conditions to which the owner would not consent if he knew it, is termed a " diversion " and a car so used is called a " diverted car " because diverted from the reciprocal line of business in which it is supposed to be engaged. While possibly cars may be diverted in some cases as much upon the one road as the other, in still other cases manifest injustice results.

The resolutions of the American Railway Association are by its constitution merely recommendatory in their character, and not binding upon any member. No adequate remedy for diversion could therefore be provided under them. The Per Diem Rules Agreement, however, was so drawn as to make the Per Diem Rules and their amendments legally binding upon the companies which signed it. The Committee on Car Service has therefore proposed to amend these rules, and impose a fine of 5 dollars for each offence upon the company which permits the diversion of another company's car. In order to define a " diversion ", the Committee has formulated a set of declarations of what constitutes the proper use of a car. These have been tentatively approved by the Association and returned to the Committee for further consideration and report. They are as follows :

Foreign cars must be handled as follows :

1° Loaded to or viâ the home road by any route ;

2° Loaded to the road from which originally received, if such loading is in the direction of the home road, but not otherwise ;

3° Loaded to an intermediate road in the direction of the home road ;

4° Loaded in the direction of any junction point with the road from which the car was received, if such loading is in the direction of the home road, but not otherwise ;

5° Cars may be reconsigned to connecting road in an opposite direction from home when permission to reconsign is obtained from the car owner, but not otherwise;

6° Empty cars belonging to direct connections must be returned to the owners regardless of whence they came or in what service they were received, except as provided in No. 11;

7° Empty cars may be sent in an opposite direction from the home road or home route if to be loaded according to Nos. 1, 2 or 3;

8° Empty cars may be delivered to connecting road to be loaded in accordance with Nos. 1, 2 or 3, but not otherwise;

9° Empty cars belonging to indirect connections must be returned to the road from which they were received if that is in the direction of the home road, but not otherwise;

10° If a road has an empty car that cannot be disposed of according to the foregoing, it must be reported to the owner and disposition arranged for;

11° Special equipment, when empty, such as refrigerators, coal, coke, stock and tank cars and other special cars, which cannot be loaded in both directions as a general proposition, shall be returned to the junction point at which delivery was made;

12° Cars handled in switching service, whether by railroads or by switching roads, shall be subject to these rules.

Any other delivery to a foreign road will be a diversion.

Considerable opposition prevails, however, to this declaration and it is by no means certain that it will be adopted.

In the meantime, a number of roads that are members of the Car Hire Agreement (referred to hereafter) have decided among themselves to put into effect experimentally an agreement as follows :

It is mutually agreed, jointly and severally, by and between the several railroad companies subscribing and parties hereto that on and after December 1, 1906, they will abide by the following Diversion Rule :

Foreign cars must be returned promptly to their owners as follows :

1° Loaded to or viâ the home road.

If such load is not available, cars of immediate connection must be delivered to the home road; cars of other roads must either be loaded to an immediate connection of the car owner, or be delivered to the home route.

2° Delivered empty to a connection for loading to the home road or home route, to be returned within four days. Such deliveries shall be indicated on the junction report by the words " For home loading. "

3° Forwarded to a foreign road when received consigned to that road.

Any other delivery to a foreign road will be a diversion for which a diversion penalty of 5 dollars must be paid to the owner of the car.

It the enforcement of these rules shall result in a considerable empty mileage without compensating loaded mileage, the case shall be adjusted on the basis of 3 cents per empty car mile, to be paid by the roads responsible.

All disputes arising under this agreement shall be settled by the Car Hire Committee.

This agreement shall terminate on July 1, 1907, unless it shall by extended, modified or dissolved, by the vote of the majority of the signers thereto, owning two-thirds of the cars represented, such action to be taken at a meeting of said signers, called be the Car Hire Committee on ten days' previous notice. In case the agreement is extended, subscribers may withdraw by giving three months' previous notice in writing to the Secretary of the Car Hire Committee.

A proposition has been made to pool all the freight cars upon a basis of their number and value, and some high officials regard this favourably. Others believe that the equitable and efficient management of so extensive a business would be found impracticable.

Another suggestion has been made to vary the per diem rate according to the value of the car based upon its carrying capacity, but this suggestion although equitable in principle would involve great difficulties in accounting. Many officials consider that this accounting would be too burdensome to make possible the practical adoption of such a plan.

Since there are now not less than 2 million freight cars owned or controlled by American railways, the value of the service of the cars, should the new rate prevail, may be reckoned at 1 million dollars per day, if at 50 cents, and at 1,500,000 dollars per day, if at 75 cents. Payments will of course be received only for the use of cars upon lines other than those of the owner, but the value of the service will certainly not be less wherever the car may be. One half the cars owned by some companies are almost constantly off their own rails. Upon others, from one fourth to one third are constantly upon the rails of other roads. The proportion depends upon the character of the local and through traffic of the several lines.

In addition to the freight cars owned by the railway companies there is a large number owned by mining and manufacturing companies and other concerns, which are called " private cars ". Accurate statistics of the total number of these is not available, but competent authority estimates them at about 120,000. A suggestion has been made, that in order to facilitate the use and movement of these private cars, their ownership should be merged in one general company. The pay ment for the use of the cars in the part of the railway companies is a matter of private contract, and is generally upon a mileage basis. They are mostly designed for a special class of lading. As they are not built for general use and for the most part cannot carry return loads, they must be returned empty to their owners.

Feeling that the situation was too acute to await the orderly action proposed by the American Railway Association which under its practice could not put the higher rates into effect before July, 1, 1907, the managing officials of a number of companies owning large equipments of freight cars called a meeting of the members of the Per Diem Rules Agreement at Chicago on November 9, 1906. At this meeting where the owners of 1,400,000 freight cars were represented, it was decided, on the part of those who desired to make the rate 50 cents per day, to form a new agreement at once among themselves. This was accordingly done, and the owners of 1,300,000 cars, about two-thirds of the entire equipment of the country, have become parties to it.

The new " Car Hire Agreement ", as it is called, does not affect those who do not sign it. In other words, the members of the " Per Diem Rules Agreement " will continue to receive and to pay 25 cents a day for the use of all cars unless they become members of the new agreement. This " Car Hire Agreement " took effect December 1, 1906, and will expire by limitation on July 1, 1907. It is assumed that by its regular methods, the American Railway Association will have raised the rate for all members of the Per Diem Rules Agreement to either 50 or 75 cents a day on the last date above named.

The curious situation will then prevail from December 1, 1906, to July 1, 1907, that two-thirds of the freight cars of the country will be in service at the rate of 50 cents per day while they are upon the lines of any of the members of the " Car Hire Agreement ", and at 25 cents a day upon all other lines; while the other one-third of the cars will be paid for at 25 cents a day wherever they may be. The penalty rate which remains on force in the latter case, has the effect, as before stated, of raising the average rate paid to about 27 $^1/_2$ cents per day, that is, on the average, its adds 2 $^1/_2$ cents per day to the ordinary 25 cent rate.

The members of the Car Hire Agreement operate about 143,500 miles of railway out of a total of 228,608 miles belonging to the members of the Association.

It is of course expected by the members of the Car Hire Agreement, that the increase in the rate of charge will have the effect of causing a more rapid handling of freight cars, and consequently their quicker relief for further service and their return to their owners. Others doubt whether this result will be realized on the ground that it will be profitable to use borrowed cars even at the higher rate, and that since the fear of the penalty rate of 1 dollar per day has been removed, cars may be retained indefinitely.

In the meantime, the American Railway Association has appointed a " Committee on Car Efficiency " which is instructed " to inquire into and report upon the causes of 'car shortage' (that is the lack of sufficient available freight cars) and the lessening efficiency of equipment and to recommend remedies ". This committee is authorized to employ expert assistance, and has had the sum of 20,000 dollars placed at its disposal. A very competent committee has been appointed and an interesting and valuable report upon the subject will be presented at the April meeting of the Association.

The great increase in the amount of traffic to be moved in all parts of the country is undoubtedly the primary cause of the shortage in freight cars. It has not only required the use of more vehicles of transportation, but has also caused a demand for more motive power. It has congested the tracks used for the delivery of freight. These latter were formerly amply adequate for the business to be transacted but have proved unequal to the present requirements.

The extent of this increased business may be understood when it is stated that the value of the agricultural products of the country for 1906 is 500 millions of dollars more than for 1905. The additional wealth thus poured into the pockets of the farmers has caused an increased demand from them for manufactured articles and still further added to the volume of traffic.

Another cause for the congestion is to be found in the operation of the new railroad rate law which took effect on August 28, 1906, and the interpretation that has been made of it by the Interstate Commerce Commission. Under the operation of this law, freight cars must be distributed alike to all shippers who ask for them. Formerly they were placed where the greatest amount of service could be secured from them. Every experienced traffic official will realize the delays and congestion that are involved in the application of such a regulation and the increased number of cars required to provide for it.

The American railway managers, have largely foreseen an increased demand for transportation and hence the enormous expenditures that have been made upon many of the lines in the construction of increased terminal facilities and additional equipment during the past year.

[656 .211 & 656 .212]

REARRANGEMENT OF THE LEIPZIG STATIONS OF THE SAXON STATE RAILWAY,

By E. TOLLER,

COUNCILLOR OF THE BOARD OF REVENUE AND OF THE BOARD OF WORKS.

Fig. 1, p. 283.

(Organ für die Fortschritte des Eisenbahnwesens.)

General remarks.

In 1902 the administrations of the Prussian State and Saxon State railways started the important undertaking of extending and rearranging the stations in Leipzig. These stations, both as regards their extent and their intercommunication, had become entirely inadequate to meet the existing requirements and the continual growth of the local and of the through traffic.

At present six stations are provided for the passenger and goods service of the city proper. Two belong to the Saxon State Railway and four to the Prussian State Railway. They are as follows :

Saxon State : *Bavaria station*, Leipzig I, in the south of the city (*see* fig. 1) for the Leipzig-Hof, Leipzig-Gaschwitz-Meuselwitz and Leipzig-Borna-Chemnitz lines;

Dresden station, Leipzig II, near the middle of the city, north of the Georgi Ring, for the Leipzig-Riesa-Dresden, Leipzig-Döbeln-Dresden and Leipzig-Geithain-Chemnitz lines.

Prussian State : *Magdeburg station*, west of and next to the Dresden station of the Saxon State, for the Leipzig-Halle-Magdeburg line;

Thuringia station, north-west of and next to the Magdeburg station, for the Leipzig-Corbetha-Erfurt and Leipzig-Zeitz-Saalfeld lines;

Berlin station, in the north, for the Leipzig-Berlin line;

Eilenburg station, in the east of the city, for the Leipzig-Eilenburg-Falkenberg-Kohlfurt line.

Most of the arrangements of these stations date back to the time at which the different lines concerned still belonged to separate companies.

The two State railways also own, jointly, the exchange station which is north-east of the Dresden station. This station which was built between 1870 and 1880 is for the exchange of goods wagons between the two State systems, and is therefore connected with the six stations mentioned above.

The intercommunication between the different stations is defective as regards the through passenger traffic. It is true that there is a double-track junction line between the Bavaria and Berlin stations, going round east of the city, over which whole trains run regularly; moreover, separate through carriages can be conveyed between the Dresden and Magdeburg stations by turn-tables, that is by a slow and cumbrous proceeding. But communication of this kind between the other stations is lacking.

In order to reduce the resulting inconvenience, omnibus services have been organized between the Bavaria, Magdeburg and Thuringia stations; but these can only be considered as a somewhat inferior expedient, as they by no means satisfy the requirements of the public in the way of speed and comfort. The electric tramways recently built give more comfortable and quicker accommodation than the bus service, but are useless for the many passengers who have luggage.

The traffic through Leipzig, which has increased materially during the last few years, suffers from these conditions, and matters have become intolerable.

Then also the accommodation now available for the passenger trains, which start from or finish at Leipzig, no longer suffices for the present traffic.

Statistical returns show that the number of passengers using the two Saxon State stations amounted, in round figures, to

1,481,000 in 1872, 1,930,000 in 1882,
3,327,000 in 1892, and 6,288,000 in 1899.

Similar conditions are to be found at the Prussian State stations.

The considerable increase in the passenger traffic since 1892, is due partly to the growth of the town in which several suburbs are now incorporated; the population was 400,000 in 1895 and 455,000 in 1900. Then also the suburbs south and east of Leipzig have grown extensively. In order to meet the requirements of this great increase in the number of passengers, the capacity of the two Saxon stations has been augmented as far as possible under the existing conditions by adding new platforms and sidings, but the possible limit was reached without supplying the accommodation which proved to be necessary.

Similar measures were adopted in the case of the Prussian stations.

For the suburban traffic, many other stations are provided : Leipzig-Connewitz, Oetzsch, Grosszschocher-Plagwitz-Lindenau, Stötteritz, Schönefeld, Paunsdorf-Stünz on the Saxon lines; Schönefeld, Eutritzsch, Gohlis, Wahren, Leutzsch, Plagwitz-Lindenau on the Prussian lines. There is a very busy traffic at these stations also, and most of them will have to be enlarged.

The goods stations, just like the passenger stations, everywhere require improvement and extension, and that urgently. The tonnage of goods transferred at Leipzig from Prussian lines to Saxon lines and *vice-versa* was 1,148,728 tons (1,130,585 English tons) in 1887 and 2 millions 426,447 tons (2,388,123 English tons) in 1899; the local goods traffic at the two Saxon stations increased from 1,052,000 tons (1,035,400 English tons) in 1877 to 1,352,000 tons (1 million 330,650 English tons). It is true that the Saxon State has built sorting sidings at Engelsdorf and Gaschwitz, and the Prussian State at Leutzsch, Eutritzsch and Schönefeld, for the trains

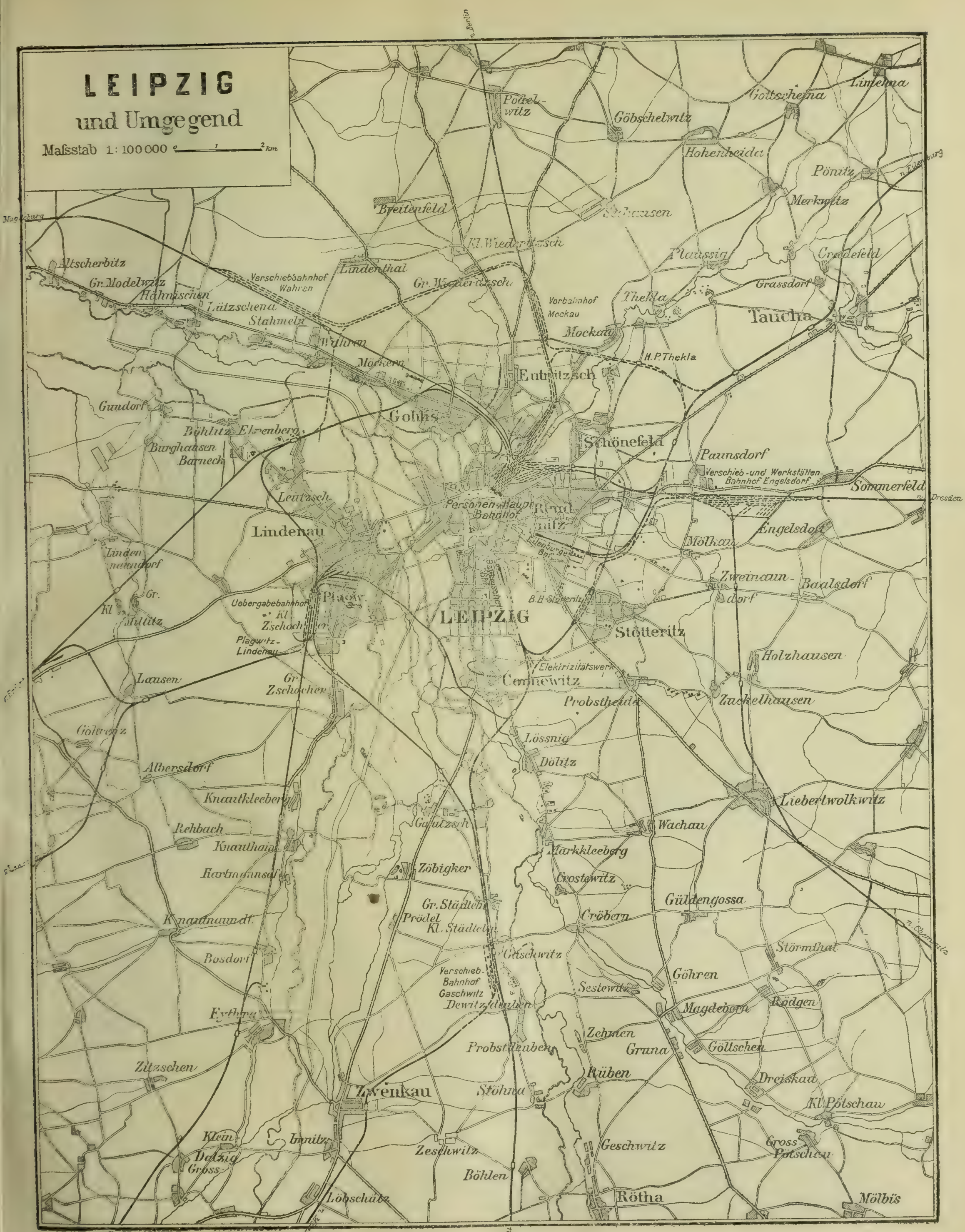

Fig. 1.

Explanation of German terms : Masstab = Scale. — und Umgegend = and environs.

coming to Leipzig; moreover, a number of the suburban stations are now also equipped for goods. The existing congestion has not however been entirely abolished, nor will it be possible to do so as long as the present condition of the Leipzig stations remains unaltered.

These unsatisfactory conditions, and more especially the deficiency in the through traffic arrangements, resulted already in December 1899 in over-congestion of the traffic, which was completely blocked at several stations for some weeks. This gave a fresh impetus to the question of rearranging the Leipzig stations.

The consideration of the question of building one chief station at Leipzig, dates back to 1874; in that year the Imperial Railway Board, when the construction of the joint goods was being undertaken, drew attention to the public complaints on the deficient accommodation for through passenger traffic and suggested that the question of building a main passenger station for all the lines, in conjunction with the joint goods station in question, should be considered.

The Saxon government then drafted a proposal, which however was rejected, in 1878, by the four railway companies concerned, the Berlin-Anhalt, the Magdeburg-Halberstadt, the Thuringia and the Halle-Sorau-Guben railway companies, because the advantages to be expected would in their opinion be more than outweighed by the estimated expenditure, 17,250,000 marks (£862,500). The matter then remained dormant for several years. In 1886, after the Prussian State had bought out the four companies, an agreement was arrived at between the Prussian State and the Saxon State radically to improve, jointly, the condition of the stations at Leipzig.

Various schemes for a joint station, either as a terminus station or as a passage station, were proposed in 1887, 1890, 1892 and 1896. Finally, the two governments in 1898 agreed that in principle it was preferable to have a terminus station for the passenger traffic, with the lines laid and connected so as to make it possible to receive separate carriages or whole trains from any direction and despatch them in any other direction without material loss of time; more particularly the trains from Berlin *via* Leipzig to Hof, as at present, and the trains from Dresden *via* Leipzig to Magdeburg or Erfurt.

An important factor in this decision was that the terminus station can be built very nearly in the middle of the town and that it is possible to place the goods station next the passenger station, that is to say also nearly in the middle of the town, as the State owns the land.

Further negociations took place and resulted in 1902 in the conclusion of an agreement between the two railways themselves, and the civic authorities of Leipzig and the Imperial Post Office authorities. In accordance herewith, new stations in and near Leipzig are to be as follows:

The joint central passenger station is to be a terminus station located in the Georgi Ring, on the site now occupied by the present Dresden, Magdeburg and Thuringia stations (*see* fig. 1). This station will receive and despatch the main line trains of all the Prussian and Saxon lines which enter Leipzig and a large proportion of the local and suburban trains. The two stations, Bavaria of the Saxon and Eilenburg of the Prussian State Railway, will be retained for local and suburban traffic.

The lines for the local goods traffic are directly connected with the central station: the Saxon ones to the east, near the Georgi Ring and the Wintergarten road, the Prussian ones to the west, near the Blücher and Eutritzsch roads.

For the main goods traffic, the two administrations will each build large sorting sidings, the Prussian State at Wahren on the Magdeburg line, and the Saxon State at Engelsdorf, on the Leipzig-Dresden line. Moreover, the Saxon State station Gaschwitz will be extended so as to serve for the preliminary sorting of the traffic of the Saxon State lines communicating with the south; the Prussian State on the other hand will build in the north an advance station at Mockau. South of the sorting sidings of Engelsdorf station new workshops will be built for the Saxon State lines going into Leipzig; these will at the same time replace the old workshops of Dresden station which will cease to exist when that station is pulled down.

The transfer of goods wagons will be carried out at two places replacing the present exchange station; the one will be in the east, at the Prussian State station Schönefeld, the other in the west, at the two stations Plagwitz and Lindenau, which are next to each other and belong to the Prussian and Saxon State respectively.

These changes in the stations involve the construction of new junction lines and the alteration of existing lines. The Saxon State proposes to have a second track on the Leipzig-Geithain line between the central station and Paunsdorf-Stünz station; to build two double-track lines from Engelsdorf station, one to the Prussian State station Schönefeld, the other to Stötteritz station; to quadruple the track of the line LHV which forms the present connection between the Berlin and Bavaria stations, between Stötteritz station and the Connewitz triangle on the Connewitz side; to rebuild the line LHV at the Connewitz triangle on the Bavaria station side; and to build a double-track line from Plagwitz-Lindenau exchange station to Grosszschocher station. Moreover, it is intended later on, to quadruple the track of the Leipzig-Dresden line from the central station to Sommerfeld station and the track of the future Leipzig-Hof passenger line from the central station to Stötteritz.

The Prussian State constructs new junction lines from Wahren sorting station to the west to Leutzsch to join the Thuringia lines and to the north to Schönefeld *via* Grosswiederitzsch-Mockau-Altnaundorf to join the Berlin and Eilenburg lines; moreover, the present Leipzig-Berlin line, along which the Magdeburg and Eilenburg lines are to run into the central passenger station (utilizing the above-named junction line) will have to be correspondingly modified on the section concerned.

The establishment of the new central and goods station at Leipzig, and of the sorting station at Engelsdorf, will necessitate sundry modifications on the Leipzig-Dresden line. This has at present three tracks between Dresden station and Paunsdorf-Stünz station, where the Leipzig-Geithain line diverges; the two tracks on the north side are used for the traffic of the two Leipzig-Dresden lines, and the south track for that of the Geithain line; further on the Leipzig-Dresden line has only two tracks.

In future, there will be six tracks from Leipzig to Paunsdorf-Stünz, and four tracks beyond to Borsdorf, as each of the two Leipzig-Dresden lines and the Geithain line are to have two tracks. But at first, the second Geithain track is only to be laid as far as Paunsdorf-Stünz, as wagons from Engelsdorf sorting station to Leipzig central must pass over that line. At the same time, provision is made for ultimately laying the third and the fourth track of the Leipzig-Dresden lines as far as Sommerfeld station, to the east of Engelsdorf sorting station; the land necessary will be purchased, and sundry constructive works are adapted to suit the final conditions, more particularly the bridge by which the Eilenburg line crosses the Leipzig-Dresden lines. The level-crossings on the section will be abolished, and the bridges will have the dimensions suitable for town traffic.

Paunsdorf-Stünz station will be shifted owing to the rebuilding of the line; more especially because the Leipzig-Geithain line is relaid in order to pass under Engelsdorf station.

The double-track junction line projected between Engelsdorf sorting station and Schönefeld exchange station branches off at the west end of the grid of the former, and turns off to the north-west. It then, describing a quarter-circle, crosses the Leipzig-Dresden line and the highway from Leipzig to Wurzen by over-bridges and joins the Leipzig-Eilenburg line at kilometres 4·2 (at miles 2·6) at Schönefeld exchange station.

The traffic on this line will be managed by the Saxon State, as it is considered best, from an economic point of view, that trains to be exchanged should be received and transferred at one and the same station, that is, at the Prussian State station Schönefeld.

The new double-track junction line between Engelsdorf sorting station and Stötteritz station also branches off at the west end of Engelsdorf grid, but turns off to the south-west to the Leipzig-Eilenburg line; it runs along the latter on a common roadbed till near the Leipzig-Hof junction line. Then it crosses under the latter and goes south-west to Stötteritz station where it joins the Leipzig-Hof junction line. The public roads are crossed by over-bridges.

This line is connected with the Leipzig-Eilenburg line by a short junction line, in order to enable special trains, and more particularly cattle trains, to run between Schönefeld and Gaschwitz without touching Engelsdorf sorting station.

The section of the Leipzig-Hof junction line, extending from the central passenger station to Stötteritz station, will in the future only be used for passenger trains; nevertheless, it is necessary to provide for the quadrupling of the line, in view of the probable growth of the already very large suburban traffic, by the purchase of land and the suitable design of sundry constructive works. Just at present, only two tracks will be laid.

On the other hand, four tracks will be laid immediately on the section from Stötteritz to the point where the line to Connewitz branches off, and on this branch itself, for this road has to carry all the local and through passenger traffic of the Leipzig-Hof line, as well as the goods traffic between Gaschwitz, the preliminary, and Engelsdorf, the chief sorting station; the two east tracks are for passenger trains and the west tracks for goods trains.

The last section of this junction line, extending to the Bavaria station, which will only be used for goods trains running between that station and Engelsdorf, will only have two tracks; but the curves will be improved and the profile will be raised so as to facilitate the widening of the cuttings.

The land inside the triangle at Connewitz, between the Leipzig-Hof line, the four-track junction line from the central station to the Leipzig-Hof line to Connewitz and the double-track junction line to Bavaria station, will be levelled down to the level of the adjacent lines, and used for an electric power station generating current for operating the electric motors and lighting the stations of all the Saxon stations in Leipzig itself as well as suburbs, including Plagwitz-Lindenau and Gaschwitz, and the Engelsdorf workshops.

The alteration in the Leipzig-Hof line at Stötteritz station will involve the reconstruction of the latter; as the goods trains will run on the west tracks, the equipment for loading and unloading goods, which is at present on the east side of the station, will have to be transferred to the west side, so as to avoid interfering with the passenger traffic. At the same time, it is to be added to, in accordance with the growth of the traffic. There will be two special tracks for goods trains, sidings for loading and unloading, with ramps and sheds, sorting and marshalling sidings.

Gaschwitz station will be altered so as to serve for the preliminary sorting of the goods traffic from the south; the goods wagons from the Leipzig-Hof, Leipzig-Borna-Chemnitz and Gaschwitz-Meuselwitz lines, going towards Plagwitz (local and through), Bavaria station, and Engelsdorf (local and through) will be sorted there.

Moreover most of the goods trains going south, and consisting of wagons from Engelsdorf, Bavaria station and Plagwitz-Lindenau will be made up at Gaschwitz.

The present station of Gaschwitz requires extension to the south and west in order to afford room for the shunting and marshalling sidings required for this service; this also involves the reconstruction of the goods tracks, the modification of the passenger tracks and of the junction by which the Gaschwitz-Meuselwitz line enters.

The exchange of goods wagons between the Prussian and the Saxon State will be effected in the west, at the adjacent stations belonging to the two States at Plagwitz-Lindenau.

Several years ago, the Saxon State station at Plagwitz-Lindenau was too small for the local traffic. Extensions were therefore begun about five years ago; the work will now be extended westwards, so as to provide accommodation for the increasing exchange traffic. The Prussian State station is being extended correspondingly.

The Prussian State line of Leipzig-Plagwitz-Zeitz will accordingly be shifted about 30 metres (98 ft. 5 in.) to the west. Moreover, a new junction line will be built from the south end of the Saxon State part of the exchange station to the south end of the Saxon State station Grosszschocher; this will make it possible to avoid the repeated shunting of through wagons while transferring them from one goods train to another. It will also make it possible for whole trains to run from Gaschwitz to Wahren and *vice versa*.

This new junction line will at first have a single track, but provision is made for a second track, and for a junction line from it to the private line Px which also extends to the proposed Saale canal dock.

The time required for carrying out all this work in Leipzig and suburbs is estimated at twelve years, so that it may be expected to be finished in 1914. The site necessary for the chief central station and the goods station in Leipzig has to be cleared, and this involves the removal of nearly the whole present Dresden station, of the exchange station and of part of the present Magdeburg and Thuringia stations; it is therefore necessary, in the first place, to provide for the sorting and exchange elsewhere. The Prussian State will therefore build Wahren sorting station and the north junction lines; the Saxon State will build Engelsdorf, Plagwitz and Gaschwitz stations and the new junction lines, and modify the other lines as proposed. This first half of the work will be completed in 1907. It will then be possible to begin the central station work in 1908. In order to avoid expensive provisional works, this work will to a large extent be carried out using the present installations, and will therefore require some considerable time. It is estimated that the first half of the office and platform buildings will be finished and in use by 1910; the present Magdeburg and Dresden stations which will be in use till 1910, will then be pulled down and the second half of the new buildings will be begun in 1911 and completed in 1914.

The construction of the Saxon State goods station was begun in 1905 and will be continued as the old installations are removed; this work will probably be finished by 1909.

According to the estimates drawn up in 1901, the work the Saxon State will carry out, not including the power station and the Engelsdorf workshops, will cost about 53 million marks (£2,650,000); namely about 13,600,000 marks (£680,000) for land, 34 million marks (£1,700,000) for constructive works, and the balance fer general expenses. The cost of construction of the Saxon State part of the new passenger station and of the Saxon State goods station will be about 27 million marks (£1,350,000).

The estimates of the Prussian State show that its expenditure in and near Leipzig will about equal that of the Saxon State. The city of Leipzig estimates that the cost of the works it will have to carry out in accordance with the agreements made will be about 17,300,000 marks (£865,000). In addition, there is the expenditure the Imperial Post Office will incur in building the parcel office north of the central station, and a new post office to the east of the Saxon State goods station, and the contributions various local authorities have to make toward the cost of building stations, widening road bridges, etc. The total expenditure in connection with the Leipzig station work will thus amount to about 130 million marks (£6,500,000).

[656 .259]

FRAHM'S SPEED AND FREQUENCY GAUGE,

By Friedrich LUX,

ENGINEER, LUDWIGSHAFEN (1).

Figs. 1 to 26, pp. 291 to 299.

(Annalen für Gewerbe und Bauwesen.)

(Abstract.)

Resonance is the property a body possesses of being thrown into energetic vibration when receiving from outside rhythmical impulses, at a rate corresponding to the period of vibration of the body in question. If two tuning forks which both give exactly the same note are placed on two sounding-boxes which are several metres apart, and if the one tuning fork is made to vibrate energetically, the vibrations are transmitted by the air to the other tuning fork, and the latter also begins to vibrate. According to Corti and Helmholtz, the Cortian fibres in our ear form a system of many thousand attuned nerve-fibres, which are acted on by sound waves entering the ear, each fibre only reacting to its own proper note; in this way we are enabled to distinguish the different notes. A remarkable instance of resonance was recorded by Professor Quincke of Heidelberg : at the Königsberg observatory a clock having a seconds pendulum of the normal type, on one occasion started, within twenty-four hours, by its beats, another clock of the same type, on another floor, which had been intentionally stopped. One sometimes notices, when playing the piano or other instrument, that windows or glasses begin to rattle; and it is easy to determine that this phenomenon only occurs when notes of a given pitch are played. Thus, this also is a case of resonance. In the domain of optics, Fraunhofer's lines are also to be considered as a case of resonance; the light waves emitted by an incandescent solid or liquid body act on the particles of the same body existing in the form of vapour, which then form a new point of emission for waves which go in all directions. Nitroglycerine and other explosives burn away quickly, if set on fire by an uncovered flame; but if disturbed by an explosion of mercury fulminate or by an electric spark, they become decomposed almost instantaneously throughout their whole mass. This is probably also a case of resonance.

Electric waves are also very suitable for producing resonance phenomena. According to Markovich, the latter enable us to multiply the tension or intensity of a current of an alternating system, to several times its initial value; and in wireless telegraphy the use of resonance for syntonizing the transmitter and receiver is an important factor in its practical success.

It has already formerly been occasionally observed, that machines when running at a given number of revolutions per minute begin to vibrate violently, and this has been called the critical speed of the machine. This phenomenon again is due to resonance. As soon as the number of revolutions corresponds to the period of vibration proper of the machine, the successive impulses begin to accumulate and set the whole machine vibrating strongly. Similarly violent vibrations, due to resonance, take place in ships or in buildings, when their own period of vibration corresponds with the rate of revolution of engines contained therein. It has even been observed that buildings, separated from the exciting engine by other buildings, have been subjected to violent vibration when the engine was running, and in order to remedy this, it was necessary to change the normal rate of revolution of the engine.

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(1) Paper read January 23, 1906, at the meeting of the *Verein Deutscher Maschinen-Ingenieure.*

Sometimes chimneys are blown down by the wind; no doubt this is in many cases due less to absolute wind pressure than to rhythmical alterations in that pressure, having a period corresponding to the period of vibration proper of the chimney. Certainly it has been observed on occasions that such chimneys, before the fall took place, executed a number of oscillations of gradually increasing amplitude, till at last collapse took place. The breaking down of bridges, especially of suspension bridges, when large bodies of men walk over in step, is also looked upon as an effect of resonance; the collapses of the Angers bridge in 1850 and of the Saint-Petersburg bridge in 1905, among others, are attributed to this cause. Many more instances of resonance phenomena could be given; I will only finally mention that during a number of years, cases have been observed of the fracture of propeller shafts in ships; the reason for such fracture could not at first be determined, as the quality of the metal used was satisfactory, and the dimensions were such that there was a high factor of safety. Mr. Hermann Frahm, of Hamburg, was the first to attribute these phenomena to resonance, and to supply experimental proof of the correctness of his theory (see *Zeitschrift des Vereins Deutscher Ingenieure*, 1902, pages 797 and 880). Frahm then struck upon the happy idea of making resonance, the disastrous effects of which he had recognized and proved in the case mentioned, serve a useful purpose by using it to measure speeds of all kinds, either on the spot or at any desired distance. We will show how he does this.

But in the first place I will try to give you, by means of some very simple experiments, a rough notion of resonance. Here is a simple stand (fig. 1) supported on three points; a ball on a thread is hung from a bent rod. If, keeping the thread stretched, I displace the ball and then release it, it oscillates with gradually decreasing amplitude until it is once more at rest. I can also set the ball swinging by giving the stand a large number of gentle taps, if I take care that the rhythm of the taps corresponds to the period of the pendulum. Moreover I can show that if the number of taps corresponds to half, one third, etc., of the number of the swings of the pendulum, the latter is set swinging more and more; but this is not the case if the former number is a multiple of the latter. We therefore note that resonance phenomena can be produced when the number of impulses is equal to the number of oscillations proper or a submultiple of the latter; but not when it is multiple.

Let us now remove the bent rod from the stand and replace it by three steel tongues of different lengths, each carrying a disk of paper (fig. 2). Here also we can readily show the phenomena of resonance, if the stand is slightly rocked at the speeds required by the different tongues.

Instead of using the hand, where the personal equation might perhaps interfere, the necessary impulses may be given by a second pendulum; for instance, we may use Galileo's double pendulum (fig. 3), with the two bobs having as nearly as possible the same period of oscillation. If a slight impulse is given to the upper pendulum, which has a mass considerably larger than the lower one, its rhythmical movements impart to the lower pendulum oscillations having an amplitude ten times or more that of the oscillations of the upper pendulum. But another phenomenon is

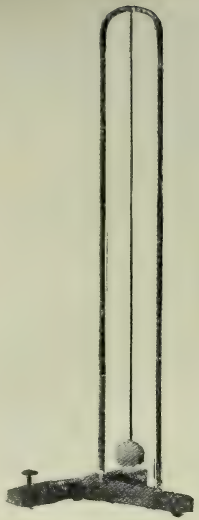

Fig. 1. — Simple pendulum.

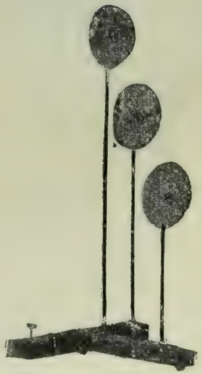

Fig. 2. — Spring pendulums with disks.

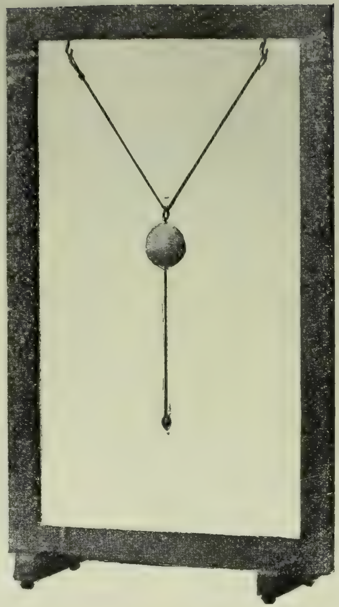

Fig. 3. — Galileo's double pendulum.

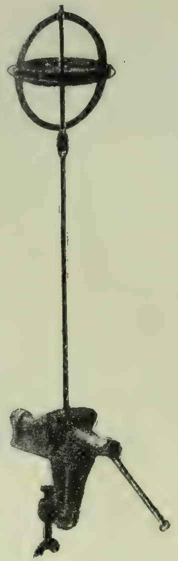

Fig. 4. — Resonance gyroscope.

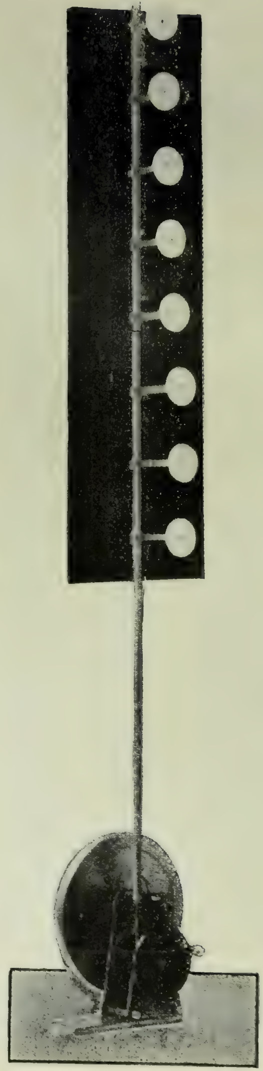

Fig. 5. — Apparatus for showing resonance effects.

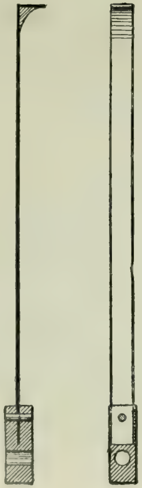

Fig. 6. — Frahm tongues, actual size.

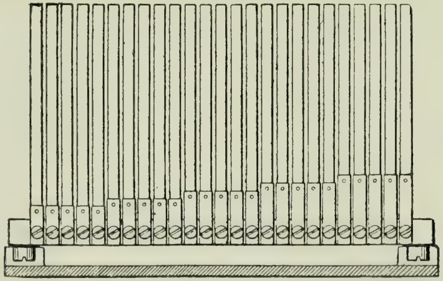

Fig. 7. — Elevation.

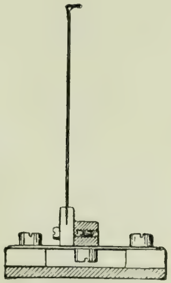

Fig. 8. — Section.

Figs. 7 and 8. — Frahm comb.

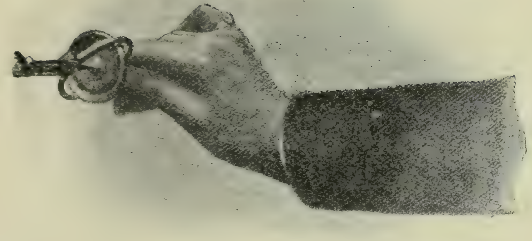

Fig. 10. — Gyroscope and comb, in action.

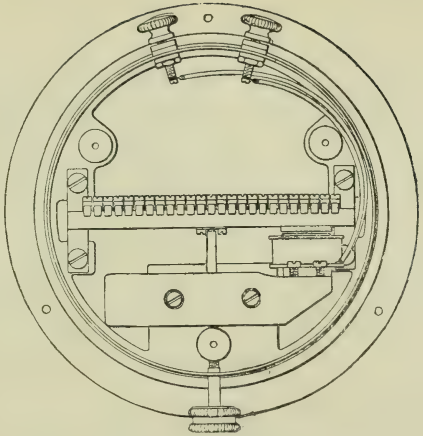

Fig. 19. — Receiver (from above).

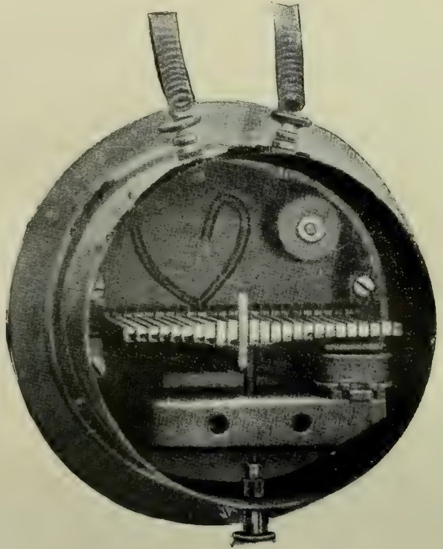

Fig. 20. — Receiver (cover removed).

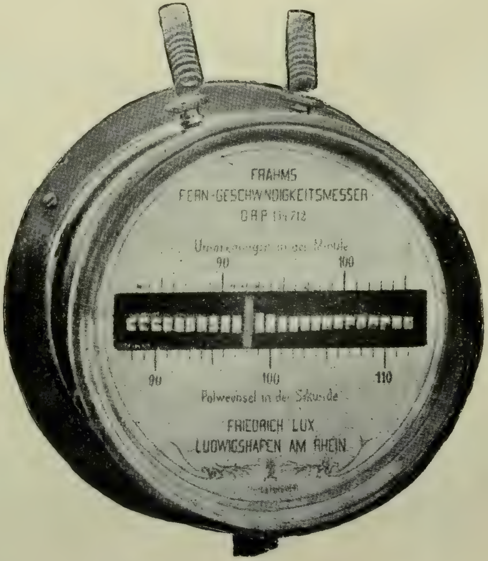

Fig. 21. — Receiver (closed).

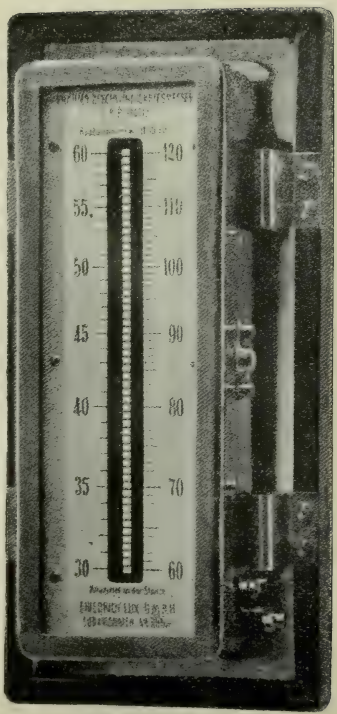

Fig. 26. — Receiver for locomotives (general view).

produced simultaneously, namely interference. The lower bob stops completely after a certain number of oscillations, then it starts again, attains its maximum amplitude, stops again, and so on. In fact, as the periods of the two pendulums are not quite equal, there is a gradual relative alteration of phase; the impulses of the upper bob gradually reduce the movements of the lower bob and in time stop it, and so on.

These two apparatus give a very fair idea of resonance; the oscillations are so slow that they can be watched by eye and counted. The phenomena are evidently the same if the speed of the oscillations increases sufficiently to make it impossible to observe the separate oscillations by eye.

The next apparatus (fig. 4) also shows us an effect of resonance in which it is still possible to follow the separate oscillations. A piece of flat steel bar, having a cross-section of about 4 by 8 millimetres ($^5/_{32}$ by $^5/_{16}$ inch) and a length of 250 millimetres (10 inches), is held at one end in a vice. At the other end, a small gyroscope is fixed, having its centre of gravity not quite in its axis of rotation; this is easily arranged by drilling a small hole or adding a small screw. Let us now set it spinning; when in course of time its speed is reduced so that the number of revolutions corresponds to the number of vibrations of the bar in one direction, its width, the bar oscillates strongly in this direction, and later on, when the number of revolutions has become sufficiently reduced to correspond to the number of vibrations of the bar in the other direction, its thickness, the bar oscillates even more strongly in this direction, which is at right angles to the former one.

In the next apparatus (fig. 5) a number of steel tongues, each with a disk of paper, is fixed to a bar. The disks of paper make any movements very visible. The bar rests at its lower end on a cam-wheel which can be turned by means of a handle. You see that as the speed of rotation increases, one tongue after another vibrates energetically. As the cam-wheel has five projections and five hollows, all that I have to do is to multiply the number of revolutions per unit time by five in order to determine the rate of vibration of each tongue; inversely, if I divide this latter number by five, I can arrive at the number of revolutions per unit of time. In this apparatus we can see all the essential parts of the Frahm resonance speed gauge; we have only to imagine the different dimensions reduced to suit the requirements of actual practice.

The essential part of Frahm's speed gauge is shown full size in figure 6; it is a tongue consisting of a strip of watch spring of best quality, made of steel or of other suitable metal. For ordinary purposes this strip is 0·25 millimetre ($^1/_{100}$ inch) thick, 3 millimetres ($^1/_8$ inch) wide and about 40 to 50 millimetres (1 $^9/_{16}$ inch to 2 inches) long; these dimensions make it possible to construct instruments of suitable size, and they suffice for most practical purposes. But they can within limits be increased or reduced to suit special cases.

The tongue is let into a groove cut in a small rectangular foot to which it is very firmly secured by riveting and soldering. At its upper end, the tongue is bent through a right angle; the bent portion, the head, is 4 millimetres ($^5/_{32}$ inch) long and enamelled white, so as to be clearly visible. A drop of soft solder is run into the corner.

The tongue is made of as homogeneous metal as possible, and its thickness is also as uniform as possible. Its period of vibration (its frequency) depends mainly on the length of the part which is free to vibrate, and on the weight added at its upper end. By using tongues between 40 and 50 millimetres (between 1 $^9/_{16}$ inch and 2 inches) long, and by adding varying amounts of solder, any desired frequency can be obtained, say within the limits of 20 and 120 vibrations per second or 1,200 and 7,200 vibrations per minute.

However, these lower and upper limits can easily be exceeded by using thinner and longer or thicker and shorter tongues; but as a general rule, the normal dimensions given above suffice.

A number of these tongues, following any given scale, are secured by screws (*see* figures 7 and 8) to an iron or brass rod having a square cross-section of 6·5 by 6·5 millimetres ($^1/_4$ by $^1/_4$ inch). A space of 1 millimetre ($^3/_{64}$ inch) is left between any two consecutive tongues. Thus a sort of comb is produced, which covers a given set of speeds. The length of this comb is practically unlimited, but in most cases, a comparatively small number of tongues suffices, say twenty-five to fifty. In some very few, three to five are enough.

This comb in secured to two thin springs, called bridges; these enable the bar to assume a slight oscillating movement in a direction at right angles to its longitudinal axis. When there are very few tongues, one bridge is enough; sometimes even this need only be fixed at one end. In some cases this elastic support is not even necessary and the comb can be fixed direct at the spot where the frequency is to be determined.

Sundry different methods may now be adopted to make the comb vibrate.

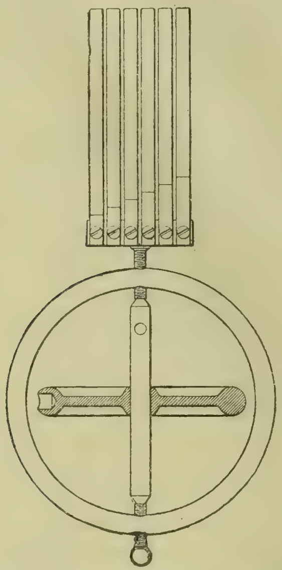

Fig. 9. — Gyroscope and comb.

It may (and this is the simplest method) be fixed, with or without bridge according to circumstances, on the frame of the machine the speed of which is to be measured.

As it probably will never be possible (except perhaps in the case of elastic shafts, such as those used in the Laval steam turbine, or in that of shafts revolving in spring bearings) to locate the centre of gravity of a rotating system exactly in its axis of rotation and to keep it there, the bearings and frames of all machinery in motion are subject to more or less intense vibration.

These vibrations are in many cases all that is required to make the corresponding tongues of a comb secured to the frame of the machine oscillate satisfactorily; the amplitude varies between a few millimetres and 30 (1 $^3/_{16}$ inch) or even more, according to the eccentricity of the centre of gravity.

A very striking experiment can be made with an ordinary toy gyroscope by fixing a small comb to its upper screw (*see* fig. 9).

In such a cheap toy it can naturally not be expected that the centre of gravity should be very near the axis of rotation. As a general rule it is markedly eccentric and consequently oscillations having an amplitude of 40 to 50 millimetres (1 $^{9}/_{16}$ inch to 2 inches) are obtained, but if by any chance the centre of gravity is only very slightly eccentric, all that is necessary is to drill a small hole into the circumference of the fly-wheel, a few millimetres in diameter and depth, in order to obtain strong oscillations : figure 10 (page 292) shows a top of this kind spinning.

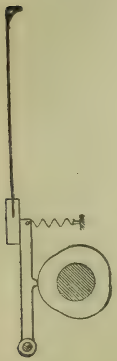

Fig. 11.
Direct
transmission.

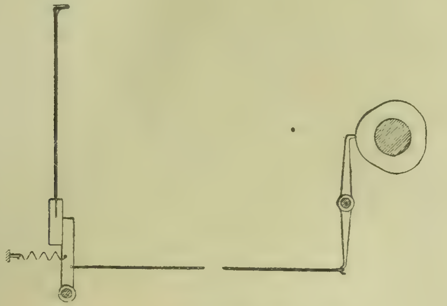

Fig. 12. — Transmission by pull.

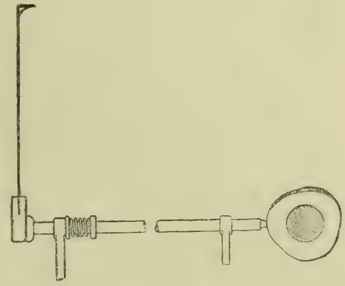

Fig. 13.
Transmission by push.

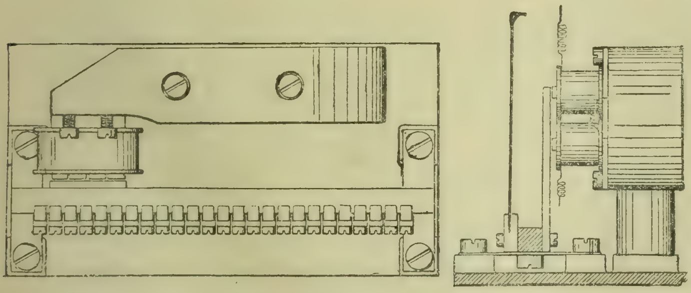

Fig. 14. — View from above.

Fig. 15. — Side view.

Figs. 14 and 15. — Electric transmission (receiver).

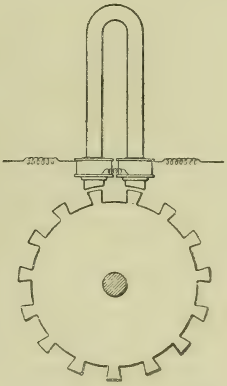

Fig. 16. — Diagram of alternator (transmitter).

The method of fixing the comb direct can be used with most high speed machines, making say 1,000 revolutions per minute or more, such as steam turbines, Pelton wheels, fans, centrifugal machines and separators. This method has given very excellent results, particularly with steam turbines, and is therefore very generally used.

The second method, also a very simple one, of actuating the comb is by the mechanical action of a cam-wheel.

Take, for instance, a shaft the rate of revolution of which is to be measured. We fix to it a disk with a certain number of projections and of hollows; a lever is brought into contact with these and so is thus made to vibrate. These vibrations can then be transmitted to a comb which is secured direct to the lever or connected with it by means of a rod, a wire or a cord.

Figures 11, 12 and 13 show three different ways of actuating the comb; oscillations can by such means be transmitted over a distance of up to about 10 metres (33 feet). But if the speed of rotation of a machine is to be measured from a greater distance, or rather from any distance, electric transmissions are used.

A piece of soft iron (figs. 14 and 15) is fixed to the bar of the comb parallel to the tongues: this forms the armature of an electromagnet the polar tips of which are fitted with coils. If an alternating current flows through these coils, the magnetic moment is alternately increased and reduced, the armature is attracted alternately more and less strongly and consequently the comb executes rhythmical oscillations; in exactly the same way as in the previously described arrangement, all the tongues are acted upon at their bases and the one having a period more or less corresponding to that of the exciting vibrations, oscillates strongly with an amplitude which depends on how near the periods agree. If the period of the exciting vibrations is exactly the same as the period of vibration of the tongue, the amplitude attains a maximum; but even when there is a difference of 2 per cent, resonance phenomena clearly appear. Hence, if tongues are tuned to 2 per cent intervals, distinct readings can still be obtained; but usually the tongues are tuned to intervals of about 1 per cent.

If for instance we want to determine the rate of revolution of an alternator, the apparatus is merely connected anywhere with the conductors, a suitable resistance being inserted, and as the frequency of alternations is an exact multiple of the number of revolutions, they can both be read direct.

If on the other hand, we want to determine the rate of revolution of any other machine which is not generating alternating current, we must use a special alternator operated by the machine, and a special conductor.

Such an alternator, of the simplest type (fig. 16), consists of a soft iron disk with teeth, revolving in front of the polar tips of a permanent magnet; these tips are inside coils. This exciting disk is either mounted on the shaft the speed of which is to be measured, or else it forms a separate apparatus operated from the shaft by means of a coupling or by spur or bevel wheels or a belt.

Such an alternator is shown in figures 17 and 18, which represent a pattern we use at present for machines in which it would be too complicated to mount the disk on the shaft direct We call this apparatus the transmitter, using the ordinary telegraph and telephone term. It is connected with the apparatus we call the receiver (fig. 19 [page 292]) by a double lead, or if the earth is used as return, by a single one; the oscillating tongues of the receiver show the speed attained.

Figures 20 and 21 (page 292) are photographic reproductions of a receiver in use. In figure 21 it is shown enclosed in its case; in figure 20 the front cover of the case is removed. It stands in my office and is connected with the system of the Ludwigshafen Municipal Power Station; it enables me to read, at any moment, the rate of revolution and the frequency of alternations of the dynamo at the station.

It is also possible to actuate the tongues by an intermittent continuous current instead of an alternating one; then we use a contact breaker of any convenient pattern, operated by the machine the rate of which is to be measured.

It follows from what I have so far stated, that a receiver operated by an electric transmission is very convenient to measure the frequency of an alternating current or the interruptions of a continuous current, or to measure the speed of machines and shafts of all kinds, a special transmitter being used or not, as may be most convenient; and such measurement may be effected at any distance. It is evident, without further explanation, that one transmitter can operate several receivers; now as waves of different frequencies and amplitudes, passing simultaneously, superimposed, through a conductor to the receiver, are again resolved in the latter, it follows that one receiver can also be operated by several transmitters. Finally, several receivers can be operated simultaneously by several transmitters; this arrangement is frequently applied in practice.

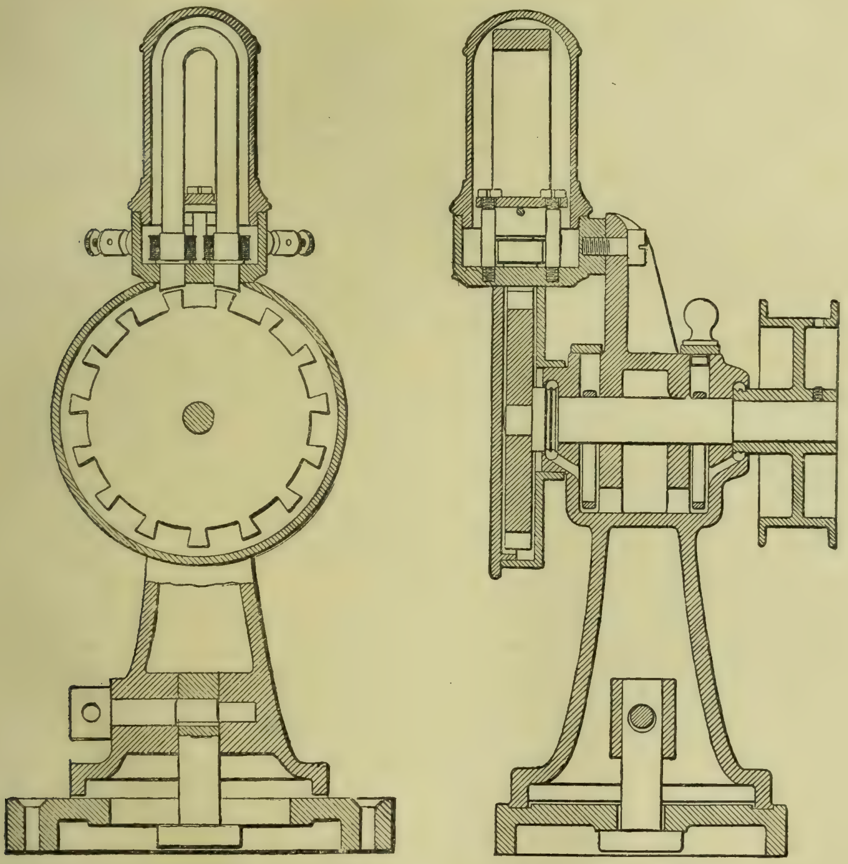

Fig. 17. — Front view and section.

Fig. 18. — Longitudinal section.

Figs. 17 and 18. — Alternator (transmitter).

It is thus possible directly to compare the frequencies of two or more alternating currents, in other words, Frahm's apparatus can be used for connecting two alternators in parallel; at the same time it acts as phase indicator or to show the slip of electromotors, etc.

The Frahm speed and frequency gauge can also be used for supervising from one point the working of any number of machines; and a centralization of control, such as was hitherto impossible, can be obtained in this way.

Practical experience and observation, during a number of years, at the ship-building yards of Messrs. Blohm and Voss, of Hamburg, have shown that the rate of vibration of the tongues, and consequently the readings of the instruments, can be looked upon as not subject to change. There are instruments which have been in constant use for nearly four years; some of the tongues, those corresponding to the normal rate of running or thereabouts, have during that time vibrated more than a thousand million times without appreciable deterioration, and they still have the same period as four years ago. The period is also not affected by the method or degree of excitation of the combs. Consequently, whether in the case of mechanical transmission, the projections and hollows of the cam-wheels are greater or smaller, or whether in the case of electric transmission, the electros of the transmitters or receivers are more or less powerful, the resistances in the conductors greater or less, the voltages or the intensities of the current higher or lower, all this in no way affects the accuracy of the readings.

In addition to the many applications for stationary installations, there are two new and great fields for the application of Frahm's gauge. Firstly, for measuring the speed of marine engines, enabling the commander to see at once if the orders given have not only been understood, but also intelligently executed; secondly, for measuring the speed of vehicles, more especially of locomotives.

I now come to the locomotive speed gauge. An alternator, which acts as transmitter, is fixed to the face of the end of a carrying axle, and generates an alternating current of varying frequency, generally of about 3,000 to 6,000 periods per minute. The alternating current is led to the speed gauge, which has a comb of fifty-five tongues suitably tuned.

The construction of this transmitter for locomotives is shown in figures 22 and 23.

The transmitter is fixed on the face of the end of one of the carrying axles, either to the right or to the left; but when possible it is most convenient to have it on the right of the trailing carrying axle, because then it is nearest the driver.

The case of the transmitter has a stop to prevent turning. Its shaft is very firmly fixed to the end of the carrying axle; for this the shaft has a flange 140 millimetres (5 $^1/_2$ inches) in diameter and 14 millimetres ($^{35}/_{64}$ inch) thick, the whole being forged in one piece. The flange, on the side at which the connection is made, has a projecting ring which enters a groove turned in the end of the locomotive axle; three studs ($^3/_4$ inch Whitworth) are screwed into the end of the axle and the flange is secured by three nuts. The holes are in a circle 100 millimetres (3 $^{15}/_{16}$ inches) in diameter. For greater safety, the studs are provided with conical collars well radiused. Limit gauges must be used in fitting the ring and studs.

The case is supported on the shaft of the transmitter; wick-lubrication is provided. It is kept in its place by a right-hand nut locked by a left-hand nut; this obviates any possibility of its working loose and at the same time provides easy adjustment.

The shaft of the transmitter also carries an inner disk, shrunk on. A number of crank pins are fixed in this disk, which form the rotating armature of the system. The number of crank pins depends on the diameter of the carrying wheels and the limits of the speed in question.

In order to determine the number of crank pins and the periods of the tongues, it is necessary to know the rolling circumference of the corresponding wheeel, when new as well as when turned up again, and the upper limit of the speed in kilometres per hour.

The metal case of the transmitter has also a bronze bearing, which can be taken out and renewed, and a cover. Three ring magnets, one above the other, are let into the case and bolted tight. The bottom one takes, by the flat faces of its ends, against two bolts with coils, which form the polar pieces; the other ends pass through the casing to within a short distance of the

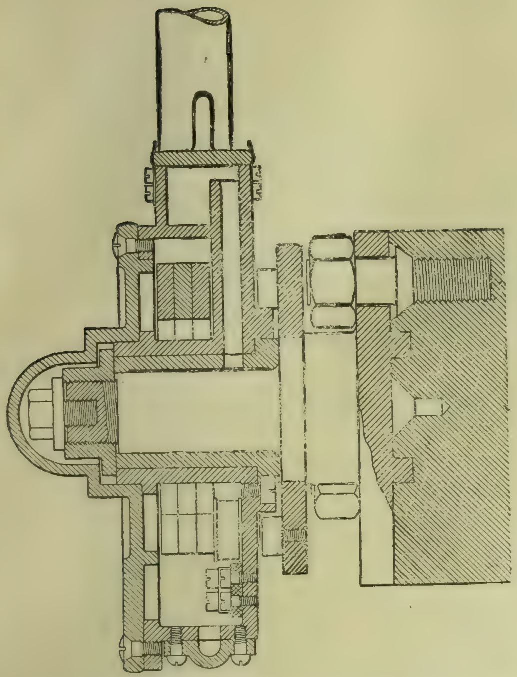

Fig. 22. — Transmitter for locomotives (section).

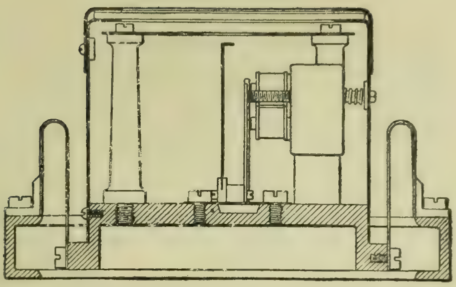

Fig. 24. — Receiver for locomotives (section).

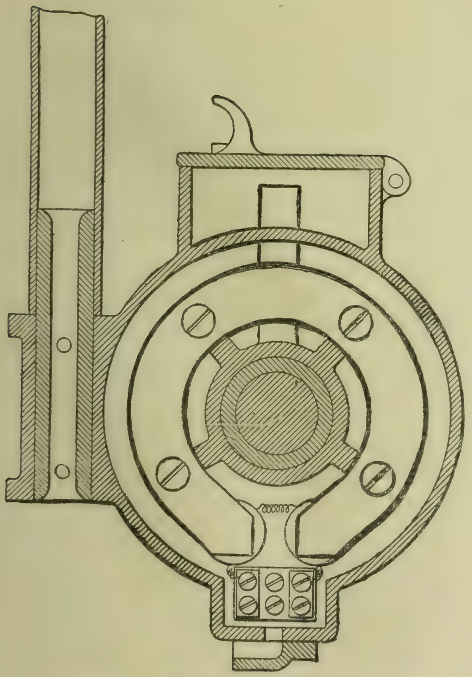

Fig. 23. — Transmitter for locomotives (inside and section).

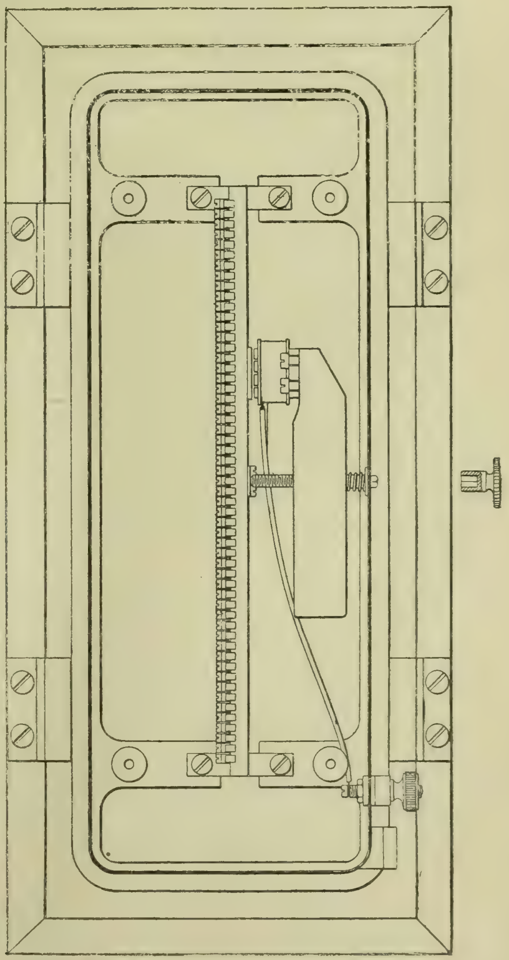

Fig. 25. — Receiver for locomotives (inside).

crank pins. When the locomotive is running, the shaft of the transmitter together with the crank pin disk is revolved by the axle, while the magnetic casing does not move; the crank pins then pass the pole pieces and generate, by the alternate opening and closing of the circuit, an alternating current which passes from the coils to the connectors which are at the bottom of the case, and then to the conductor. The transmitter case is kept in place by means of a steel tube with one end of which it is firmly connected. The other end of the tube is freely hung from the locomotive frame so as not to interfere with the many relative movements of the frame and wheel. The cable from the transmitter is also in this tube and leads to a connector fixed to the frame near the end of thè tube. From this connector another cable leads to the receiver. This arrangement makes it unnecessary to open the case of the transmitter when the carrying axle is renewed.

The upper end of the tube of the transmitter must be arranged so that it has free play in every direction, even in the vertical one, while at the same time effectively preventing the rotation of the case of the transmitter.

The instrument which shows the speed, the receiver, is shown in figures 24, 25 and 26 (page 292) (cross-section, inside, outside); it is fixed in a position where the driver can conveniently see it. In order to prevent the tongues from being oscillated by the vibrations of the locomotive, the case is hung by steel springs from a frame made of channel iron, measuring 375 by 175 millimetres (1 ft. 2 $^3/_4$ in. by 6 $^{29}/_{32}$ inches) outside. It is best secured, by means of hook screws, to the right of the cab about 1·5 metres (4 ft. 11 in.) above the foot-plate.

On the outer side of the case of the receiver, the cable is held in a clamp and its two wires are secured by binding screws; the other end of the cable goes to the connector near the end of the tube of the transmitter.

The regulating screw is operated by a special key; after the instrument has been adjusted on a trial run, the key is kept in the custody of the authorities.

The graduation plate is fixed by screws to four uprights, and can be replaced by another corresponding to the rolling circumference of the carrying wheels when the latter has been altered by being turned up again. Mr. Wittfeld, to whom the design of the locomotive transmitter is chiefly due, has proposed to replace this graduation plate by two triangular vertical prisms placed to the right and left of the row of tongues. These prisms have on their three faces the graduations corresponding to the wheel when new, when turned up again once and when turned up a second time. The prisms are placed outside the case, and then lead-sealed so that they cannot be tempered with; this arrangement has the great advantage that the case need then not be opened, which has to be done when the present graduation plates are changed.

In a locomotive with two cabs, one transmitter can actuate two receivers. Similarly, in addition to the receiver in the cab, a second receiver placed for instance in the guard's van, can be operated by the one transmitter if it is thought advisable for the guard to watch the speed.

The Prussian State Railways have at present ninety locomotives fitted with Frahm speed gauges, and the results obtained up to date show that this system will satisfy the requirements of the service when some small defects are eliminated, such defects not being inherent to the system but due to sundry peculiarities in the service to which the instrument is not yet completely adapted.

[551 .51 & 621 .59]

ELECTRIC ANEMOMETER,

By R. GOLDSCHMIDT,

FELLOW OF THE UNIVERSITY OF BRUSSELS.

Figs. 1 and 2, pp. 302 and 303.

(*Bulletin de la Société belge d'électriciens.*

In the anemometers hitherto used, the speed of the air or gas is measured by its action on a mass (wind-wheel, vane, etc.); the movement of the mass gives a reading which is the more inaccurate and sluggish the greater the inertia of the system which the wind has to overcome. The apparatus here described depends on an altogether different principle. It is well known that if a platinum wire is inserted in an electric circuit it becomes heated and its resistance increases with the temperature. If such a wire is cooled, either by lowering the temperature generally, or by destroying, by disturbing the surrounding air, the equilibrium of temperature established between the wire itself and the circumambient air forming a warm layer round it, any ammeter in the circuit will at once show a decrease in the resistance of the wire.

In the apparatus here considered, the variations in the temperature of the platinum wire will be produced by the action of the wind; the faster the wind, the more the wire will be cooled. But there is another factor which may influence the resistance of the wire, namely the temperature of the air itself. The strength of the current which the wire will allow to pass will therefore not by itself give an accurate anemometric measurement.

In the proposed method, the resistance of a platinum wire exposed to the wind is compared with that of an exactly similar wire, but protected against the wind and only affected by the temperature of the circumambient air.

These two wires are shown in the diagram by the letters P and P_1 (fig. 1).

Examination of this diagram shows at once that the anemometer wire P and the temperature-compensation wire P_1 form two branches of a Wheatstone bridge. The resistances X and X_1 form two other branches of the bridge through which current is supplied from the battery. If the wires P and P_1 are both protected against the wind, their resistance will be equal and the galvanometer will stand at zero, the resistances X and X_1 being also equal. If the temperature of the whole system rises or falls, the simultaneous variation in the resistances of the two wires, placed under the same conditions, will not affect the position of the galvanometer needle.

As figure 1 shows, the wire P_1 is sheltered from the wind by a cylindrical cover and a metal cap, so that it is protected against any movements of the air; at the same time its temperature will always vary with that of the air, and the changes in its resistance will compensate the exposed wire, the resistance observed thus becoming, up to a certain point, independent of the variation of temperature of the air and dependent only on its velocity.

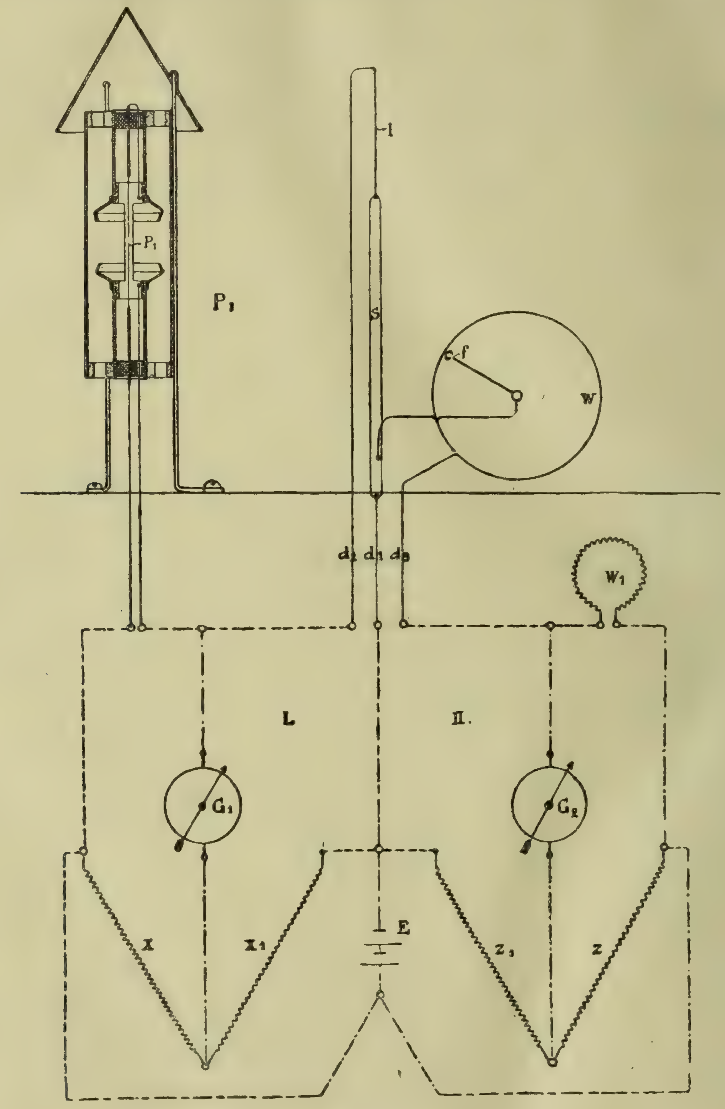

Fig. 1.

In order to graduate the galvanometer and enable it to measure the speed of the wind, a very simple apparatus is used, by means of which any required velocity is imparted to the anemometer wire, the air being considered as at rest.

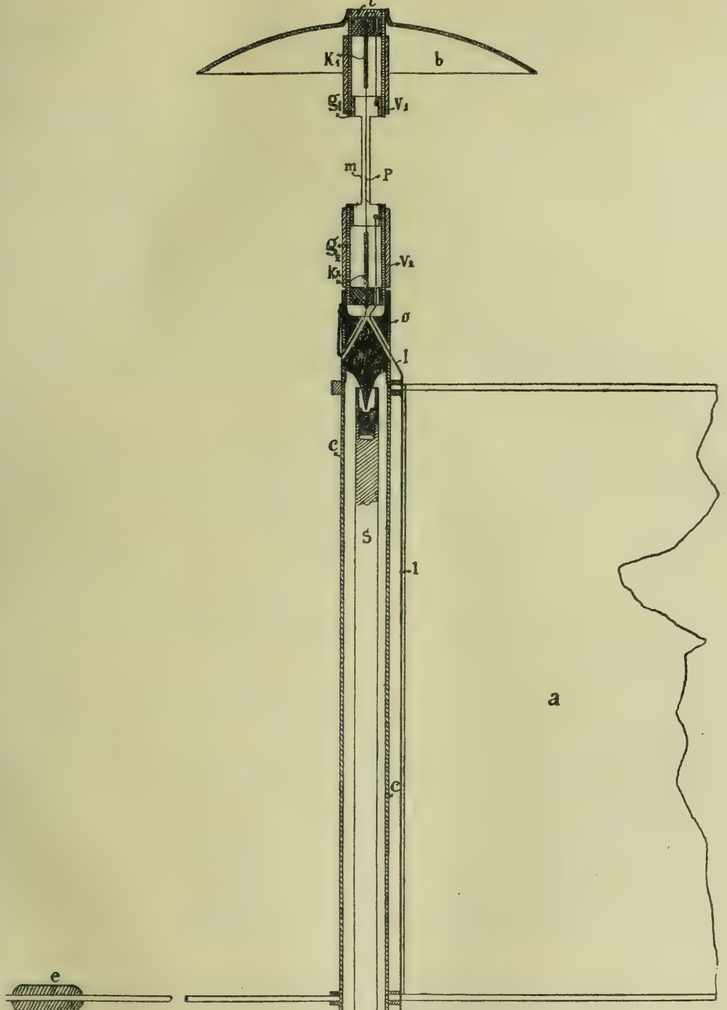

Fig. 2.

The system consists essentially of a horizontal disk supported on a vertical axis; the platinum wire to be calibrated is fixed vertically on the disk and supplied with current, being placed more or less eccentrically.

The number of revolutions per unit time is counted; the distance of the wire from the centre of rotation of the disk then enables the speed in the air to be calculated.

Let us assume that the galvanometer is deflected α when the wire has a velocity v, the air temperature being t^o. If then the wire is placed in a wind of temperature t^o and the galvanometer shows a deflection α, we may conclude that the velocity of the wind is v.

As we have remarked above, a characteristic feature of the apparatus is that there are no masses to be moved; the inertia is represented merely by the thermal capacity of the wire heated. Another still more important feature is to enable the measurements of the velocity of the wind to be taken at a considerable distance from the instrument exposed; the conducting wires from the branches of the Wheatstone bridge to the galvanometer can be long without affecting the proper action of the system.

By using a self-recording galvanometer, the variations in the air currents may be automatically recorded. As it is often of importance in meteorology to supplement the determination of the wind velocity by a record of its direction, a weather-cock is added to the instrument described above; its movements can be recorded at a distance by electricity.

As shown in figure 2, plate *a* forming the vane is fixed to the tube *c* closed at the top by the cover *o* which terminates in a point.

This point forms a pivot which rests in a hole at the top of rod S. The latter is firmly secured to the box *h* which serves both as base of the whole apparatus and as receptacle for different electric resistances and contacts.

The cover *o* carries the case in which the essential part of the anemometer system is contained.

The platinum wire P is soldered at its two ends to copper rods k_1 and k_2 which are kept central to the glass tubes g_1 and g_2 by ebonite stoppers. The glass tubes are kept apart by the distance pieces *m*, which consist of thin sheet copper placed in the same direction as the vane. Thus the platinum wire is held, while the wind has free access to it.

The current enters the rod S by wire d_1, passes through rod k_2, wire P, rod k_1, wire *i*, copper strip *m*, and wire *l*. It then reaches a circular cup containing mercury forming a contact for wire d_2. The lower and enlarged part of tube *c* has inside a fixed contact *f* which can move relatively to a circular wire W, forming a resistance which is connected with the lead d_3 shown in the figure. If the current passes through d_1, S, *c*, *f*, W, d_3, and the wire W forms the branch of a Wheatstone bridge of which the resistances w_1, z and z_1 form the other branches, any movement of the vane will alter the resistance of W and can consequently be read on the galvanometer, previously adjusted so that a definite position of the contact *f* relatively to the wire W corresponds to one division of the galvanometer.

[621 .133.5]

AMERICAN ENGINEER TESTS ON LOCOMOTIVE DRAFT APPLIANCES.

Figs. 1 to 9, p. 307 and 310.

(*American Engineer and Railroad Journal.*)

An elaborate series of tests on locomotive draft appliances were made in 1894 in Hanover, Germany, by Messrs. von Borries and Troske (*American Engineer and Railroad Journal*), 1896 (¹). The Master Mechanics' committee on exhaust nozzles and steam passages presented excellent reports on these subjects in 1894 and 1896, the tests being made on an actual locomotive on a testing plant. In the *American Engineer and Railroad Journal*, June, 1900, Mr. H. H. Vaughan presented an article in which the need of further and more exhaustive tests on front-end arrangements was discussed. In 1901, the *American Engineer and Railroad Journal* conducted an extensive series of tests on locomotive draft appliances at Purdue University, the results of which were presented in this journal during the years 1901, 1902 and 1903. At the 1902 Master Mechanics' convention, a committee was appointed to assist the *American Engineer and Railroad Journal* in carrying out these tests. At the 1905 meeting of the Association, the committee reported that liberal contributions had been received from over seventy railroads and from the two leading locomotive companies for carrying the tests to completion. A recommendation was made by the committee and adopted by the Association, that the results of these tests should be published in the *American Engineer and Railroad Journal* when they were concluded. The committee has just completed its work and presents the following report. An appendix, which accompanies the report, gives a more elaborate presentation of methods and results :

REPORT OF COMMITTEE ON LOCOMOTIVE FRONT-ENDS.

To the President and Members of the Master Mechanics' Association :

The undersigned, your committee, appointed to " assist in the tests being conducted at Purdue University, Lafayette, Ind., by the *American Engineer and Railroad Journal*, and to carry on the tests outlined in its report to the convention in 1903, " respectfully submit the following :

Historic statement. — The Association as early as 1890 had appointed a committee to report on the best forms of exhaust-nozzles and steam-passages. This committee, after making one

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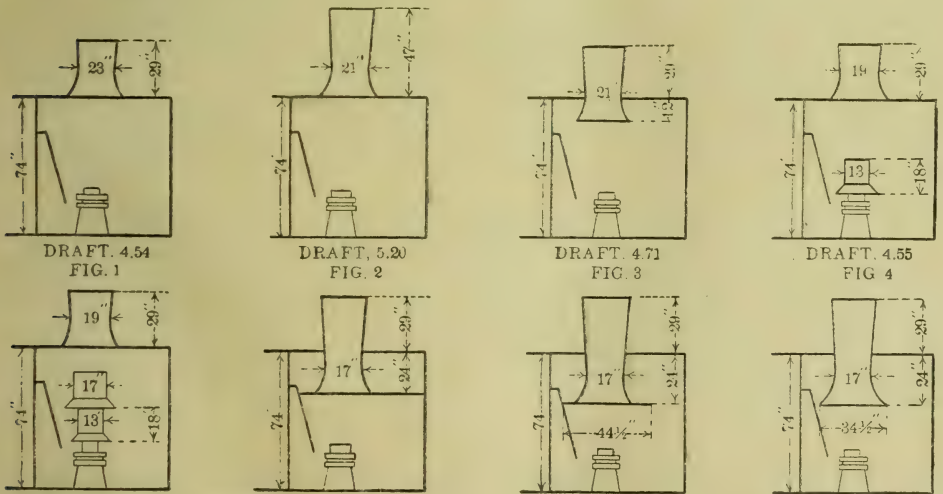
(¹) See *Bulletin of the Railway Congress*, No. 7, July, 1897, p. 911 : " Experiments on the form and dimensions of locomotive exhaust-pipes and chimneys ", by Mr. von Borries.

report, and after being continued for several years, finally gave way to a new committee under the chairmanship of Mr. Robert Quayle, with the result that in 1896, an epoch-making report was presented. The work of this committee settled two important questions, *viz.*, the action of the exhaust-jet and the form and proportions of the exhaust-pipes and nozzles.

In 1901, the *American Engineer and Railroad Journal* became the patron of Purdue University for the purpose of advancing an experimental study embracing the form and proportion of locomotive stacks, and invited and secured as an advisory committee the assistance of distinguished motive power officials. By virtue of this arrangement, an elaborate investigation was planned and completed, with results which were expressed in the form of general equations, by the use of which it was assumed that the stack for any engine might be correctly proportioned. The results of this investigation appeared in the columns of the *American Engineer and Railroad Journal* during the following year. These experiments, however, were made upon an engine having a diameter of boiler of but 52 inches, which is far less than that of the modern locomotive, and they were chiefly concerned with the problem of the outside stack. In consequence of these facts, there was a common desire to have the experiments repeated upon a locomotive of large size, and to have the study extended to include the draft-pipe problem, the effect of inside stacks and of false tops in the smoke arch. In response to this feeling, the Association in June, 1902, laid the foundation for the work which finds its completion in the present report. It was at this time that your committee was appointed. A year later, the committee made a report, giving a summary of the work already accomplished, and presenting an outline of such additional work as was most needed. It reported that Purdue was ready to proceed with the work, that the New York Central Railway Company was prepared to loan an engine of large size for the use of the committee, and they submitted an estimate of the cost of the experiments they proposed. This report was received, and the committee continued for another year, since which time it has each year made a report of progress and has been continued. New York Central Atlantic type locomotive No. 3929 was delivered to the University Laboratory in November, 1905, and continued to occupy the testing laboratory until the following April. During this interval, there were obtained the results herein described.

Co-operating influences.— First among those to whom acknowledgment is due, is the *American Engineer and Railroad Journal*, by whose enterprise the original investigation was outlined and by whose efforts substantial progress in its development was achieved. While its formal contribution has long since been submitted, its interest has not failed, and your committee acknowledges with pleasure the assistance which from time to time has been rendered by representatives of this journal. The Standard Oil Company has presented your committee with one of the several carloads of fuel oil needed. Seventy-four railway companies made contributions of money to meet necessary expenses. The New York Central lines have contributed, without charge, the use of a locomotive for a period of five months ; they have delivered the locomotive to the University Laboratory, and received it back again from the laboratory, without expense to your committee. They have also made the necessary experimental stacks and draft-pipes from drawings supplied by your committee, and fitted the same to the engine upon which they were to be used. Purdue University has contributed the use of its laboratory and the time of its expert staff, the costs to your committee having been only such as have arisen from the supplies consumed and the time of necessary extra attendants. The tests have been under the direct supervision of professor W. O. Teague, assistant professor of experimental engineering, whose report, which accompanies, covers all details of the tests. It is the belief of your committee also that professor Teague has been enthusiastically assisted by Mr. L. Endsley, instructor in engineering laboratory in charge of the locomotive testing plant. To all of these, as well as to others, too numerous to mention, your committee respectfully acknowledges its indebtedness and returns its thanks.

Outside stacks. — The tests of outside stacks involved two different heights, namely, 29 and 47 inches. The 29-inch height only is practicable for road conditions upon the locomotive under test. Stacks of each of these heights were supplied in diameters ranging from 15 to 21 inches by 2-inch steps, and as the work proceeded, it seemed desirable to extend the range with the result that, in the 29-inch height, stacks of 23 and 25-inch diameter respectively were added to the series. In these tests, no draft-pipes nor nettings were employed in the front-end; the diaphragm and exhaust-pipe were the only details present. Under these conditions, with a 29-inch height, the best diameter was found to be 23 inches, though this was not much better than that of 21 inches. With a 47-inch height, the best diameter is 21 inches. The exact arrangement of equipment for the best results is shown by figures 1 and 2. The notation under these figures and under those which immediately follow gives the draft obtained with a constant back pressure of 3·5 lb. It will hereafter appear that there are better arrangements than that shown by figure 1. The point which is proved is that, assuming a plain outside stack 29 inches high to be used, its diameter for the best results is 23 inches, as given.



DRAFT. 4.54
FIG. 1

DRAFT, 5.20
FIG. 2

DRAFT. 4.71
FIG. 3

DRAFT. 4.55
FIG. 4

DRAFT, 4.40
FIG. 5

DRAFT, 5.06
FIG. 6

DRAFT, 5.05
FIG. 7

DRAFT, 4.98
FIG. 8

Figs. 1 to 8. — Best arrangement of each type of front end tested.

A comparison of results obtained from a large locomotive with those previously obtained from a smaller locomotive. — Among the more important conclusions drawn from the *American Engineer's* tests of 1903, the following are of especial interest in connection with the present discussion :

That for a tapered stack, the diameter for best results does not change with changes in height.

That the diameter of stack is somewhat affected by the height of the exhaust tip, the diameter for the best results being greater as the nozzle tip is lowered.

That, calling d the diameter of the stack at its smallest part, and D the diameter of the front-end, the relation between the diameter of stack and front-end when the exhaust tip is at the center of the boiler is

$$d = 0{\cdot}25\mathrm{D}$$

That the diameter of stack must, for best results, be increased 0·16 inch for each inch that the exhaust tip is below the center-line of the boiler; that is, calling h the distance between the center-line and the tip

$$d = 0{\cdot}25\mathrm{D} + 0{\cdot}16h.$$

That a variation of an inch or more from the diameters given by the equation will produce no unfavourable result.

In view of the publicity that has been given these statements, it is important to determine the extent to which their truth is affected by the experiments of the present year.

As to the necessity for varying the diameter with the height of stack, the work of the past year is far less elaborate than that of 1903, but two heights of stack having been employed, namely, those of 29 and 47 inches respectively. Comparing draft-values obtained from stacks of each of these heights under a uniform back pressure of 3·5 lb., it appears that the best diameter for the 29-inch stack is 23 inches. The best results from the 47-inch stack were obtained by use of the largest diameter experimented upon (21 inches). Curves plotted through the several points show this diameter to approach that for the maximum draft, but it does not equal it. The indication is that if a diameter of 23 inches had been employed, it would have been found right for the 47-inch height as well as for the 29-inch height. There is, in fact, nothing in the experiments of the present year to invalidate the conclusion derived from the preceding work. So far as outside stacks are concerned, therefore, the diameter does not need to be varied when the height is changed.

As to the effect, upon the proportions of stack, resulting from changes in the height of the exhaust tip, it must be noted that the work of the present year has involved one height of tip only, and hence gives no information upon this question. The validity of the conclusion already stated, however, has never been called in question, and it may be assumed to stand.

Concerning the actual size of stack for best results, the work of the present year points to the desirability of using diameters which are somewhat larger than those given by the equation of 1903. This equation is

$$d = 0{\cdot}25\mathrm{D} + 0{\cdot}16h.$$

which, when applied to the N. Y. C. locomotive experimented upon, gives

$$d = 0{\cdot}25 \times 74 + 0{\cdot}16 \times 12{\cdot}5 = 18{\cdot}5 + 2{\cdot}0 = 20{\cdot}5$$

whereas, with a stack 29 inches high, the best results were actually obtained when the diameter was 23 inches. The difference of 2·5 inches is not great, especially in view of the fact that it has been distinctly noted that variation of an inch or more is not important. The difference is to be accounted for also by the fact, that in reviewing the results of 1903, there was a common feeling on the part of the members of the advisory committee, that the experiments pointed to dimensions which, for service conditions, were excessive. Because of this view, the equation was framed as a conservative expression of the experimental results. The data obtained during the present year might, for like reasons, be similarily treated, in which case the discrepancy of 2·5 inches would be diminished or even be eliminated. Since, therefore, the only element of doubt concerning the results of 1903 has found expression in beliefs that they gave diameters which were too large, it is the feeling of your committee that the work of the present year may be accepted as a full confirmation of the earlier work.

Having shown the value of the work of the present year in confirming the conclusions of 1903, it remains to consider those phases of the present year's work which are to be regarded as extending beyond the scope of the earlier investigations, the effect of which necessarily diminishes the importance of that which has preceded. It will be shown that, however well the plain outside stack may be proportioned, the demands of service require it to give way to a more highly articulated device.

Inside stacks. — The experiments included inside stacks of four different diameters, ranging from 15 to 21 inches, a constant outside height of 29 inches and a penetration into the smoke-box of 12, 24 and 36 inches respectively. The best proportions of this form of stack are shown by figure 3 accompanying. Its diameter is 21 inches and its penetration (P) into the smoke-box is 12 inches. Results of nearly the same value were, however, obtained with stacks of smaller diameter having greater penetration. Thus, 21-inch diameter, 12-inch penetration, gave a draft of 4·71; 19-inch diameter, 24-inch penetration, gave a draft of 4·55, and 17-inch diameter, 36-inch penetration, gave a draft of 4·32. From the values thus presented, it appears that as the degree of penetration increases, the diameter of stack should be reduced. The effect is, in fact, of the same nature and degree as that which results from raising the exhaust-tip. It is noteworthy also that these values for the plain inside stack, are not materially better than those for the plain outside stack, a fact which was formulated as a conclusion resulting from the work of 1903.

Inside stack with false top. — It had been planned to fit the front-end with three different false tops located at 12, 24 and 36 inches respectively from the top of smoke-box, but the presence of the steam pipes made it difficult to fit the 12-inch top, and as a consequence only the 24- and 36-inch drops were experimented upon. In each case, stacks of different diameters wese used, the outside height being always 29 inches. The best results were obtained with a stack 17 inches in diameter, having a penetration of 24 inches, all as shown by figure 6. In all cases with the false top, the 17-inch stacks gave best results. A comparison of these results with those quoted for plain outside stack and for plain inside stack, show material improvement in draft values.

Substitutes for false top. — The false top necessarily interferes with free access into the front-end, which fact makes it desirable that a way be found in which to secure the results derived from it by means which are more simple. It was suggested that experiments be made to determine the effect upon the plain inside stack of an annular ring or flange which might be considered as representing a portion of the false top. Responding to this suggestion, rings of two diameters were used on 17- and 19-inch stacks having a penetration of 24 inches. It was found that the proportions shown by figure 7 gave substantially the same results as those obtained with the best arrangement of false top. Believing that the results thus obtained pointed to the desirability of having a broader curve at the base of the stack, and that when the proper proportions were understood, the best results would be obtained from such a curved surface, the 17-inch stack was fitted with a bell, to which, for purposes of experimentation, flanges of various widths were afterward added, with the result that those proportions which appear in figure 8 proved most satisfactory. It will be noted that the best draft with the false top was 5·06; with the ring, 5·05, and with the bell, 4·98. That is, these three arrangements are practically on an equality. No other arrangements were experimented upon which gave higher draft values than these.

Single draft-pipes. — Draft-pipes of various diameters, adjusted to many different vertical positions, were tested in connection with plain stacks of the several diameters available. The elaboration of this phase of the work was very extensive. It was found that for the best results, the presence of a draft-pipe requires a smaller stack than would be used without it, but that no possible combination of single draft-pipe and stack could be found which gave a better draft than could be obtained by the use of a properly proportioned stack without the draft-pipe. While the presence of a draft-pipe will improve the draft when the stack is small, it will not do so when the stack is sufficiently large to serve without it. The best proportion and adjustment of a single draft-pipe and stack are shown by figure 4.

Double draft-pipes. — Double draft-pipes of various diameters and lengths, and having many different positions within the front-end, all in combination with stacks of different diameters, were included in the experiments with results which justify a conclusion similar to that reached with reference to the single draft-pipe. Double draft-pipes make a small stack workable. They cannot serve to give a draft equal to that which may be obtained without them, provided the plain stack is suitably proportioned. The arrangements and proportions giving the best results are those shown by figure 5.

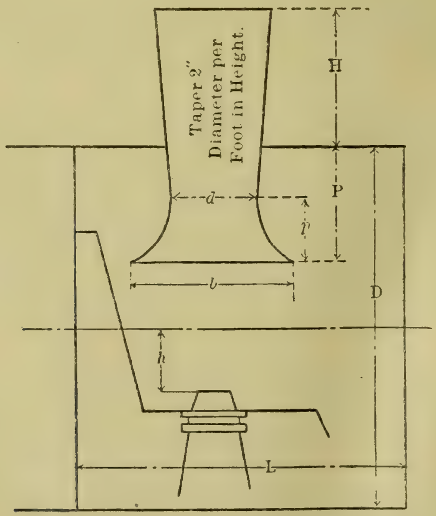


Fig. 9. — Best arrangement of front end.

The length of front-end. — The experiments involving different lengths of front-end only appear to be inconclusive. The range of these experiments included the length of front-end normal to the locomotive, which is 65·75 inches, with successive reductions therefrom of 4 $^1/_2$, 8 $^7/_{16}$ and 20 inches respectively, obtained in each case by fitting in a false-front. The fitting was well done, the work being made practically tight, notwithstanding which fact it was found that the longest and shortest ends experimented with, gave practically identical results, while the lengths between these limits gave results which were somewhat inferior. The peculiar character of the results as first obtained, led to a complete duplication of the work after a considerable interval had elapsed, with results which were identical with those first obtained. So far as the experimental results give a solution to this problem, they point to a length of 66 or 46 inches as equally satisfactory and suggest that intermediate lengths are to be avoided.

A suggestion as to a standard front-end is presented as figure 9, which, with the following equations referring thereto, may be accepted as a summary of the conclusions to be drawn from all experiments made.

For best results, make H and h as great as practicable.

Also make, $d = 0{\cdot}21\text{D} + 0{\cdot}16h$
$b = 2d$ or $0{\cdot}5\text{D}$
$\text{P} = 0{\cdot}32\text{D}$
$p = 0{\cdot}22\text{D}$
L = (not well established).
$= 0{\cdot}6\text{D}$ or $0{\cdot}9\text{D}$ but not of intermediate values.

While the drawing is a simple one, to be put forth as a result of so elaborate a series of experiments, it goes without saying that the latter have been valuable quite as much for the things they prove useless as for the proportions of details which they serve to define. For example, it will be seen that the suggested standard does not include draft-pipes, and that it includes a stack of comparatively large diameter having a bell as the lower end of dimensions quite beyond those now common in American practice.

Respectfully submitted,

H. H. Vaughan,
F. H. Clark,
Robert Quayle,
A. W. Gibbs,
W. F. M. Goss,
G. M. Basford,
Committee.

[385. (07.11 & 727 .4]

THE NEW ENGINEERING BUILDING OF THE UNIVERSITY OF PENNSYLVANIA.

Fig. 1, p. 313.

(*Engineering News.*)

A new building for the Engineering Department of the University of Pennsylvania was formally dedicated on October 19, 1906, and is with little doubt the finest, largest and best equipped structure devoted to instruction in engineering in the United States, if not in the world. The formal exercises in connection with the dedication of the new building were held in its auditorium on the afternoon of October 19 and were attended by a large number of invited guests representing the principal engineering schools of the country. The keys of the building were formally presented to the Honourable Chas. C. Harrison, provost of the University, by Mr. Emlyn L. Stewardson, of the class of 1884, on behalf of the architects of the building, Messrs. Cope and Stewardson. The honorary degree of doctor of science was then conferred by the provost on a number of distinguished engineers, including the presidents of three national engineering societies : Mr. Frederic P. Stearns, of the American Society of Civil Engineers; Mr. Frederick W. Taylor, of the American Society of Mechanical Engineers; and professor Samuel Sheldon, of the American Institute of Electrical Engineers. The same degree was conferred upon general Alexander Mackenzie, chief of engineers of the United States Army; admiral Charles Whiteside Rae, chief of the Bureau of Steam Engineering of the United States Navy; professor Mansfield Merriman, for twenty-eight years professor of Civil Engineering at Lehigh University; Mr. Ramon Ivarrola, the official representative of the Mexican government at the dedication; Mr. Samuel M. Vauclain, superintendent of the Baldwin Locomotive Works; professor H. W. Spangler, head of the Department of Mechanical Engineering of the University; professor Edgar Marburg, head of the Department of Civil Engineering of the University; and the venerable John Fritz, the Nestor of the iron and steel industry of the United States. Following the conferring of these degrees, a portrait of the late J. Vaughan Merrick was presented to the University. The remainder of the dedication exercises was occupied by two addresses : the first was given by Mr. Frederick W. Taylor, comparing the discipline and methods of the University and of industrial establishments; and the concluding address was by Mr. Alexander C. Humphreys, president of Stevens Institute of Technology, on " The Engineer as a Citizen. " The remainder of the afternoon was devoted to the examination of the new building, a full description of which is given below.

In the evening, a dinner was given at the Union League Club by the alumni of the Engineering Department. A large number of invited guests were present, and the total number seated at the tables was about 300.

The history of the Engineering Department of the University of Pennsylvania dates back to 1872, but the growth of the department was slow until some twenty years later, when a new building was constructed for the mechanical and electrical engineering departments. The rapid growth of all departments in the engineering school, however, soon overtaxed the facilities provided, and some five years ago plans were matured for the completion of the present new building.

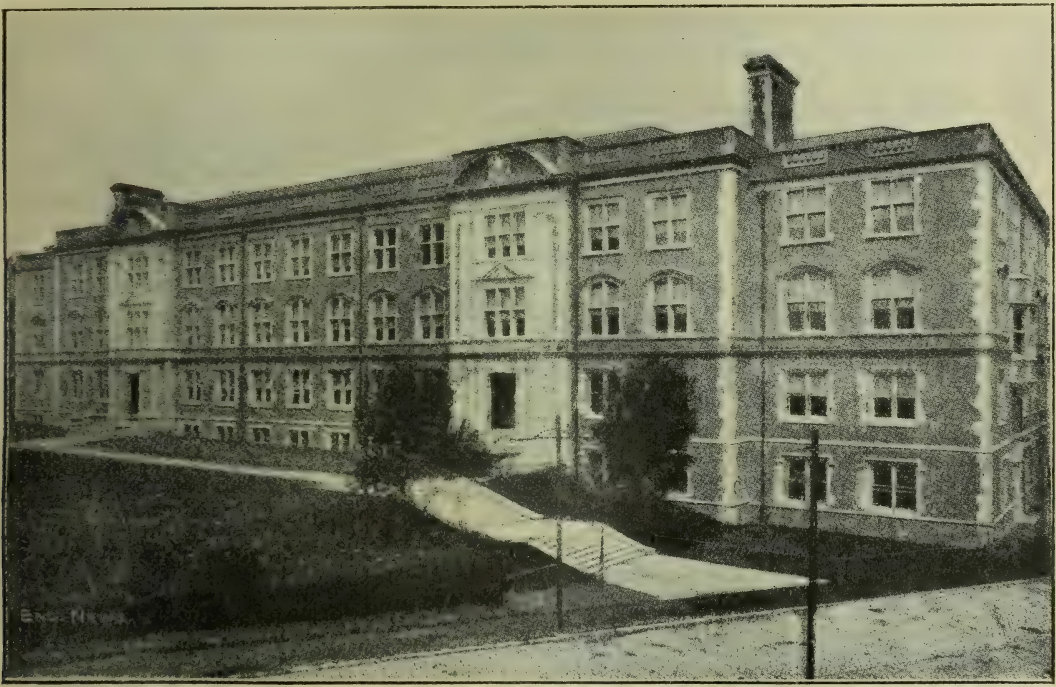


Fig. 1. — The new engineering building of the University of Pennsylvania, dedicated on October 19, 1906.

In its construction, the experience of engineering institutions the world over has been sought and made use of, and it is believed to be a model in every respect for the work to be performed. A detailed description of the building is as follows :

The building has a frontage of 300 feet, with a depth of 210 feet at one end and 160 feet at the other. There are three stories, with a basement covering about one-third of the entire building. The total floor area is 128,000 square feet. The foundations are of concrete carried 28 feet below the lower level. Steel construction is used throughout. The floor arches are of hollow tile. The floors are of hard pine, excepting those in the halls, which are finished in marble and those in the laboratories which are of concrete.

The exterior of the building is of dark colored brick with limestone trimmings, and the general architectural treatment, as shown in the figure 1, is in the English-Georgian style. For the roof, steel trussed girders with a slate covering are used. The approximate cost, including equipment, was about $1,000,000.

The building is heated by steam, each room being fitted with steam coils supplied by exhaust steam from the central station. The ventilation is by electrically-driven fans, located in the attic and in the basement. The ventilating system is divided into sections, each with a separate fan and tempering coils, so that only that portion of the building in use has fresh air pumped into it. The fans may be controlled from any room in the building. The lighting is by electricity.

The basement contains the machinery for heating and ventilation, locker rooms, lavatories, the storage battery rooms, laboratories for geodetic and hydraulic work and for the testing of materials of construction. On the first floor, adjacent to the main entrance, are the offices of the heads of departments, the east end of the building being devoted entirely to the Civil Engineering Department, and the west end to the Mechanical Engineering Department. On the second floor a reference library, capable of holding 20,000 volumes, and a reading-room occupy the central space at the front of the building. The library is flanked on either side by a series of recitation and lecture-rooms. There is also a students' assembly-room with about 2,500 square feet of floor space. At the rear are the drawing-rooms, the alternating-current laboratory, and the repair shop. On the third floor is a large room for the engineering societies, a general supply store, class rooms, instructors' rooms, drawing-rooms and a large room for an engineering museum.

Two principal entrances lead to the main hallway, which extends east and west the entire length of the building, with staircases at both extremities. Two large light-wells terminate in skylights over the ground floor.

A feature of the laboratory equipment worthy of note is the practice, wherever possible, of providing separate apparatus for individual students. Each man is thus enabled to work alone and be held responsible for the results turned in by him; also for the apparatus assigned to him. In cases where this plan would not be feasible, as, for example, in obtaining the steam consumption of an engine, one student is the leader and another the helper at one laboratory period; at the next laboratory period the student who formerly was the helper then assumes the leadership, running a test on the same engine but under different conditions. In each case the leader is responsible for the test, and the observations taken belong to him. Each student is thus obliged to work up a complete set of observations and, in consequence, the results are the same as if each man were making the test alone.

In the laboratories, one instructor is provided for about every eight students. Owing to each student being advised some time beforehand as to the apparatus that will be at his command, the systematic outlining of the experiments on advance sheets, and the access to the engineering library in the building, the ratio of 1 to 8 undoubtedly gives better results than could otherwise be expected.

The cement laboratory. — The cement laboratory occupies a floor space of about 1,700 square feet, and is divided into two parts, the larger part being devoted to testing cement, and the smaller part to concrete work and experimental research.

The larger room contains four large slate-top mixing tables, each fitted with a damp-closet, locker and drawers, and two balances. The waste is discharged through chutes conveniently located. Graduated burettes are mounted on these tables through which water a normal temperature can be accurately and quickly obtained. The testing apparatus consists of an Olsen and a Riehlé lever machine, electrically driven, a Fairbanks and a Falkenau-Sinclair machine, and a 50,000-lb. hand-power hydraulic machine for compression tests. This room also contains an Olsen mechanical briquette-molding machine, a Howard & Morse automatic sifting apparatus for sand and cement, and a Bauschinger expansion apparatus. Nine soapstone immersion tanks, subdivided, piped for the hot and cold water, and fitted with overflow discharge connections, enable a continuous flow of water to be maintained at any desired temperature. One of these tanks is supplied with zinc racks for the storage of small briquettes. A large soapstone damp-closet is provided for large briquettes and beam molds.

The smaller room contains a mixing table, boiling apparatus for accelerated tests, a drying oven for use in specific gravity and absorption tests, and a large concrete immersion tank capable of accommodating concrete beams 13 feet long. A beam crane is used for the convenient handling of the beams and their transference to a carrying frame mounted on casters, which latter is used to convey them to a 200,000-lb. Olsen testing machine across the hall. This testing machine is fitted with a beam extension 15 feet long, designed for a working load of 120,000 lb. It is operated by a direct-connected 5-horse-power, two-speed electric motor, and is equipped with an autographic attachment for recording stress-deformation diagrams. The entire equipment of the cement laboratory was the gift of Mr. Robert W. Lesley.

The testing materials laboratory. — The laboratories for testing materials other than cement occupy a floor area of about 3,300 square feet. Two rooms in the basement and one room on the first floor are devoted to this purpose. The floor of the latter is of massive reinforced concrete construction, supported on steel beams and designed for a working load of 500 lb. per square foot.

The largest machine to be used for testing has a capacity of 600,000 lb. It is an Olsen, vertical four-screw machine of the universal type, capable of receiving a column 24 feet long, and is provided with beam extensions below the floor level 21 feet long designed for a load of 200,000 lb. on a span of 20 feet. This machine is under contract but not yet installed.

The testing equipment comprises, in addition to the above, a 200,000-lb. Olsen machine, a 100,000-lb. Olsen machine, two 30,000-lb. Olsen machines, one 30,000-lb. Falkenau-Sinclair machine, one 60,000-in.-lb. torsion machine, an autographic pendulum torsion machine of the Thurston-Riehlé type, a 10,000-lb. transverse machine, a cold-bend machine capable of bending a steel bar 1 square inch in section, and a 15,000-lb. wire-testing machine. With the exception of the transverse, the wire-testing, and the pendulum torsion machines designed for hand operation, all of these machines are electrically driven by independent motors.

Extensometers, compressometers and shearing apparatus are also installed, and a small room in the basement contains two rattlers for testing paving bricks, which may be operated singly or jointly by an electric motor. For the preparation of test specimens and for the construction and repair of apparatus, a well-equipped machine shop is provided in the basement.

The geodetic laboratory. — A spacious, well-lighted room in the basement, entirely above the ground level, is devoted to this work. The surveying instruments are stored in this room, and piers and large tables are provided for indoor work, especially during inclement weather. The equipment consists of a large assortment of instruments used in ordinary engineering practice, and a variety of instruments of greater precision for geodetic surveying.

The hydraulic laboratory. — About 6,300 square feet of floor-area are devoted to hydraulic work, there being a spacious room in the basement, one directly overhead on the first floor, and a small room on the second floor, occupied by the testing apparatus.

A circular, vertical, steel pressure tank 5 1/2 feet in diameter and 37 feet high extends from the basement floor to the second-story ceiling. This tank is provided with orifice devices designed to permit of changes in the orifice plates while the tank is under pressure. The maximum working pressure is 65 lb. per square inch, corresponding to a head of 150 feet. The piping is so arranged that the tank can be brought under the pressure of the city water mains, under the pressure of the water in a stand-pipe extending a few feet above the roof of the building, or under higher pressures by direct pumping.

The pressure tank discharges into one of a pair of reinforced concrete tanks each 34 feet long and 5 × 5 1/2 feet in cross-section. Perforated pipes and baffle screens are used to break up the current. The two tanks are connected by a sluice gate so that they may be used jointly as a single calibrated measuring tank of 13,000 gallons capacity. The arrangement of the weir plates at the extremities of these tanks is such that weirs with and without end contractions may be obtained, as well as discharges through orifices under low heads. The lowest end plates are hinged, and by swinging these plates down, the tank may be converted into a canal across which dams of different profiles may be placed for investigations on the flow over dam crests.

The weirs discharge into a reinforced concrete reservoir of 23,000 gallons capacity, and provision is made for weighing the discharge before it passes into this reservoir. From the reservoir the water is pumped by three Worthington 4-inch, two-stage pumps each driven by a 35-horse-power electric motor. Each pump has a capacity of 450 gallons per minute against a maximum head of 165 feet.

An important feature of this laboratory equipment is a stand-pipe 12 inches in diameter and 65 feet high, extending from the basement floor to a short distance above the roof of the building, and connecting with the main pipe circuits and with the pressure tank at top and bottom. Circular overflow weirs are provided at frequent intervals in the stand-pipe for testing apparatus under a constant static head of predetermined height up to 65 feet. For greater pressures connection is made with the pressure tank. An 8-inch tubular well 110 feet deep is also provided for efficiency tests and experiments with air lifts and deep well pumps. The laboratory is equipped with a 9-inch turbine and a 12-inch reaction wheel, suitably mounted for efficiency tests; also with an excellent assortment of water meters and a great variety of minor apparatus.

The mechanical laboratory. — The total floor space devoted to mechanical laboratory purposes is 14,000 square feet on the ground floor. This space is occupied by a standard room, a boiler plant, testing floor, a producer room, gas engine laboratory, heating rpom, refrigerating room, steam laboratory, dynamometer laboratory, hydraulic testing apparatus, and the apparatus already described for testing materials.

The steam, exhaust, and water piping is run overhead. Steam at 100 lb. pressure is supplied from the University central light and heat station, the exhaust piping also connecting into the general exhaust system. Power outlets are distributed throughout the laboratory for the various motor drives. The main lighting is done by arc lamps suspended from the ceilings, with outlets at convenient points for the connection of portable lights. Three runways, with travellers and chain hoists, provide facilities for handling the heavier machine parts.

The boiler testing plant contains a 100-horse-power Roberts water-tube boiler, a Wainwright feed heater, and a Worthington duplex feed pump, together with the necessary weighing tanks, etc. The whole plant can carry steam at 250 lb. per square inch, the steam line leading over the testing floor which is of iron plate 13 × 12 feet, with water, steam and exhaust outlets at disposal. A Wheeler cooling tower, a row of gas engines ranging in size from 3 to 30 horsepower, and a 1-ton ammonia ice machine with refrigerating chamber and ice tanks, are also provided. Space has been left for a gas engine to be run directly from a suction producer that will later be installed.

A very complete line of engines, condensers, injectors, etc., constitutes the steam laboratory. In the dynamometer laboratory are two belt-driven dynamometers and a railroad oil tester. For hydraulic work in the mechanical laboratory, tanks are provided for water meter calibration, and for nozzle calibration. Pump tests are made on a 2-inch centrifugal pump, and there are three water-wheels : a Doble impulse wheel, a Pelton wheel, and a Leffell reaction wheel, mounted respectively on three flume tanks. In addition to the above, there are two Ericsson hot-air engines and a Deming motor-driven triplex pump; also an instrument room used for coal calorimetery, gas analysis, gage-calibration, indicator and planimeter examination, and microphotographic work.

The electrical laboratory. — Five rooms are devoted to electrical work. In every case, provisions are made so that one experiment may be carried on entirely independent of every other one. The five rooms are devoted respectively to instrument testing, direct-current machine testing, alternating-current machine testing, and two rooms to photometry.

The instrument room has a floor area of 4,500 square feet, part of which is enclosed for an apparatus room, instructors' offices, and a storage battery room. It is on the ground floor and nearly all under skylight. There is a table and a galvanometer pedestal for each student, twenty-four students in all being provided for. The tables consist of two concrete pillars, each about 2 feet high, and carry a slate slab 26 × 44 inches, and 1 $^1/_2$ inch thick. The pedestals are located immediately in front of the tables, and are built of one large concrete pillar capped with a slate slab 15 × 44 inches, and 1 $^1/_2$ inch thick. They are of the same height as the tables. This method of construction reduces vibration to a minimum.

There are four marble switchboards with wires running to each of the tables just mentioned. All the wiring is rubber covered and runs below the floor level in concrete drains covered with rolled-steel floor-plates. Each switchboard is fed by a battery of eighty storage cells and also with 110 volts from the dynamos. Either alternating or direct current is available from the switch-boards, and as a source of energy for elementary work, about twenty-five primary batteries are provided.

For direct-current machine testing, there is utilized about 2,000 square feet of space on the ground floor. The machines are placed upon raised concrete foundations from 4 to 8 feet square. The foundations are approximately 6 inches in height, and on top of them are placed wooden runners of 3 × 4-inch yellow pine at a distance of about 6 inches apart. On the top of these wooden pieces are iron straps laid at right angles to them. The irons are screwed to the wood, which is bolted to the concrete. The machines rest upon the iron strips, and the vibrations produced by the machines are taken up in the wood. A slate terminal board is placed at each test stand, and on this 500 amperes are available at 110 volts; also battery current at 6 to 150 volts.

The alternating-current machine testing occupies about 2,100 square feet on the second floor; this space, however, includes the photometer rooms. A 4-kilowatt Wagner alternator, a 1-kilowatt Westinghouse alternator, a 2-kilowatt Westinghouse alternator and a 1-horse-power Holtzer-Cabot alternating-current motor, together with a 14-foot switchboard thoroughly fitted, and about ninety measuring instruments, comprise the equipment. The photometer rooms have dull black walls and labyrinth entrances. A storage battery of seventy-six cells furnishes current for photometer work. Each room has a photometer with a 3-meter track and universal rotating stand. One photometer is equipped with a Lummer-Bodhun screen and one with a Bunsen screen.

The work shop. — About 12,000 square feet on the ground floor are used for a work shop, in which there are a wood shop, pattern shop, foundry, iron shop, machine shop, forge shop, tool repair shop, and a large tool room.

The drawing-rooms. — The drawing-rooms are located on the north side of the building on the second and third floors, and cover a space of 11,800 square feet. The windows, being wide and high, admit an abundance of light. General Electric 110-volt enclosed arc lights, with opaque lower globes and concentric diffuser shades, furnish the artificial illumination. The number of lights and their location are such as to eliminate all shadows. A drawing table and stand are assigned each student. Both are built of red oak, except the table tops, which are white pine 30 × 54 inches. The tables were especially designed and contain a drawer for instruments, etc., and a closet at one side for boards and T-squares. Both drawer and closet are fitted with combination locks. A Franklin automatic, continuous-feed, electric blue-printing machine, and a blue-print frame for printing by sunlight, are installed. Suitable washing tanks and driers are also provided, and these are placed close to the printing apparatus to facilitate the handling of the blue-prints.

PROCEEDINGS

OF THE

SEVENTH SESSION

WASHINGTON : MAY, 1905

5th SECTION. — LIGHT RAILWAYS.

[656 .27]

QUESTION XIX.

ORGANIZATION OF A CHEAP SERVICE

ON A

MAIN RAILWAY'S BRANCH LINES WHICH CARRY LITTLE TRAFFIC

AND ON

LIGHT RAILWAYS.

(3rd AND 5th SECTIONS JOINTLY.)

◆

Simplifications in the conveyance of passengers, parcels (express packages) and goods. Special motors and rolling stock.

Reporters :

All countries, except America, Austria-Hungary, Germany and Holland. — Mr. Joseph Rocca, ingénieur, inspecteur principal chef à la direction générale des chemins de fer italiens de la Méditerranée.

Austria-Hungary, Germany and Holland. — Mr. Cornel de Tolnay, inspecteur principal, chef d'exploitation des chemins de fer de l'État hongrois.

QUESTION XIX.

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PRELIMINARY DOCUMENTS.

Report No. 1 (all countries, except America, Austro-Hungary, Germany and Holland), by Joseph Rocca. (See the *Bulletin* of December 1904, p. 1839.)

Report No. 2 (Austria-Hungary, Germany and Holland), by Cornel de Tolnay. (See the *Bulletin* of February, 1905, 2nd part, p. 797.)

Vide also the separate issues (in red cover) Nos. 20 and 32.

SECTIONAL DISCUSSION

(3rd AND 5th SECTIONS JOINTLY.)

Meeting held on May 10, 1905 (morning).

MR. VON LEBER, PRESIDENT OF THE 5th SECTION, IN THE CHAIR.

The President. (In French.) — In Mr. Rocca's absence, will Mr. de Tolnay kindly summarize both his own report and that of Mr. Rocca?

Mr. de Tolnay, *reporter for Austria-Hungary, Germany and Holland.* (In French.) — The economies to be realized in the management of railways and the simplifications which may be introduced in their operation, form a vast subject which has at all times occupied the attention of railway managers and will continue to do so. The importance of this feature is considerably greater in the case of light railways, as their moderate receipts make economy indispensable.

Eighteen years ago, at the Milan meeting, Messrs. De Busschere and Dejaer treated the subject in detail in their report, as well as in their remarkable work which was published at the same time, and furnished an absolutely complete account of all the steps taken in this direction by different managements. Five years later, Mr. Lewis handled the subject at the St. Petersburg meeting and presented a very remarkable report, containing among other things a collection of the legislative measures adopted by different governments, relating to light railways. The object of these legislative measures is in part to afford certain facilities for the construction of light railways, such as doing away with fencing, gates at grade crossings, etc. Certain legislative authorities also exempt light railways from taxation during a longer or shorter period. All these measures were discussed in connection with Mr. Lewis' report at St. Petersburg, and as no important changes have been made since that time in the countries with which I am concerned, it is unnecessary to dwell too long on this point. In view of the discussions mentioned and the report of Mr. Rocca, it will suffice to mention some improvements recently introduced on the railways of Austro-Hungary, Germany and Holland.

As regards the management proper, the tendency is to separate the service of the light railways from that of the main lines, especially as regards the officials entrusted with the maintenance of the permanent way and the operation. This tendency appears to arise from experience of the fact that light lines, to be well managed, require attention to details, which could not be expected from officials in charge of more important affairs.

As to technical working, it may be stated as a fact, that almost all managements are satisfied to have the track inspected once or twice per day, and some of them have done away with track watchmen, replacing them with common labourers employed on maintenance work, who inspect the track in the morning on their way to work. Others entrust this task to the foremen of maintenance gangs. To simplify the station service, a great many managements restrict the passing of trains to certain stations, with a view to reducing the number and grade of employees at other stations. However, it is only at few stations that it can be arranged to prevent trains from passing each other, for, however few trains are running, the schedule will require a passing point at least every 20 kilometres (12·4 miles). To reduce the number of employees at passing points, it would be necessary to do without their cooperation in matters affecting the movements of trains; all these matters for the entire line must be concentrated in the hands of a single official. An arrangement of this kind has been in effect experimentally on one line about 60 kilometres (37 miles) long — belonging to the Hungarian State Railways — for nearly six months, without developing any disadvantages. A similar measure might overcome another difficulty encountered at small stations, *viz.* : the complexity of tariffs. An employee of limited education is scarcely qualified to understand all the rules for the application of tariffs and in addition, international tariffs are a delicate subject to handle. It might perhaps be practicable to entrust the application of tariffs to an official living at the junction station. One of the most efficient methods of reducing operating expenses will always be the reduction of the expense of traction. Now, the number of trains cannot well be reduced without causing dissatisfaction to the public or even reducing receipts. The running of mixed trains for this purpose, only partially meets the reasonable demands of the public, while the separation of freight from passenger traffic always involves some increase in the number of trains. To avoid an excessive increase in the cost of the service, the only course is to reduce the weight of the trains and the number of employees. Legislative and other measures devised for this purpose, such as doing away with brake vans, running locomotives without a special fireman, etc., were fully discussed in the papers of Messrs. De Busschere and Dejaer. There is nothing to add except the question of automotor cars, the importance of which is constantly increasing. The reporter does not think himself entitled to enter into the details of construction. He confines himself, therefore, to mentioning some results obtained.

On the Wurtemberg State Railways, there were in operation in 1903, five petroleum cars of the Daimler system, seven steam cars of the Serpollet system, and one electric accumulator car. The average run of these cars was 31,717 kilometres (19,708 miles). The expense per 100 kilometres (per 100 miles) was :

For the Daimler car :

Fuel	12·06 francs	(15*s*. 6·32*d*.).
Lubrication	0·60 —	(0*s*. 9·27*d*.).
Maintenance	4·64 —	(5*s*. 11·69*d*.).
Total. . . .	17·30 francs	(£1. 2*s*. 3·28*d*.).

For the Serpoilet car :

Fuel	5·90 francs	(7*s*. 7·15*d*.).
Lubrication	0·56 —	(0*s*. 8·65*d*.).
Maintenance	8·91 —	(11*s*. 5·65*d*).
Total. . . .	15·37 francs	(19*s*. 9·45*d*.).

These results, and those obtained on different Hungarian railways, lead to the hope that automotor cars will be the means of increasing the number of passenger trains without any considerable growth in cost. Still, the technical solution of this problem does not seem as yet to have been sufficiently perfected.

The question is not one that can be precisely answered. I, therefore, felt that no absolute conclusions should be proposed.

The President. (In French.) — You have just heard, gentlemen, the summary Mr. de Tolnay has given us of both the reports. In these reports, there are a large number of interesting details to which we can pay no attention in drafting our conclusions, because the legislative enactments in the various countries represented here are quite different.

As the systems of operation differ in different countries, we cannot draw up definite or quite precise conclusions, but it would be of interest if the delegates present would kindly acquaint us with what is being done in their respective countries, what simplifications ought to be introduced to favour lines of local interest, and what means are to be recommended to lower expenses.

So I hope several delegates will speak on this subject. I declare the subject now open for discussion.

Mr. J. Rostern, Great Central Railway, Great Britain. — Mr. Chairman and gentlemen, I wish to draw attention to page 42 of the report of Mr. Rocca, which reads (¹) :

> Outside France and Italy, the only railways on which on some of the trains there is only the driver on the locomotive, are the Caledonian Railway, the North British Railway and the Great Central Railway in Great Britain, and the New South Wales Government Railways.

(¹) See *Bulletin of the Railway Congress*, No. 12, December, 1904, p. 1878.

I do not quite know where Mr. Rocca obtained the information regarding the Great Central Railway of England, but I should just like to place on record the fact that there must be some misunderstanding as regards that, because on the Great Central Railway of England, we have no locomotive which has only one man on the engine, and I would just like that to be corrected.

With regard to page 45 of the same paper by Mr. Rocca, it would lead the reader of this paper to believe that the only railways in Great Britain having adopted the automobile system are the Taff Vale, the Great Eastern, the North Eastern and the South Western railways. As regards this point, I should also like to say that the Great Central Railway some little time ago constructed two automobiles, two motor cars, very similar in construction to the cars in use on the Great Western Railway of England. These cars convey both 1st and 3rd class passengers, as well as baggage of a limited amount, and will seat something like sixty passengers. We also have for some time past been considering the question of using one of these motor cars on lines which have hitherto only been used for the conveyance of goods traffic, where the gradients are very heavy, and I should like to know if there are any other railways, whether in Great Britain or America or on the continent, where on very heavy gradients motor cars have worked with great satisfaction.

The President. (In French.) — If no one wishes to address the meeting now, I shall take the liberty of saying a few words on this interesting subject, although, as a matter of fact, the subject of gradient is of comparatively second rate importance, and every difficulty can be surmounted if the arrangements thereby involved are carefully adopted, namely by providing suitable power for the cars and motors.

We have already discussed question XX which was considered by the 4th and 5th sections jointly. In the course of that discussion, we were told that in England there are motor cars giving excellent results, when the gradient is slight.

We heard that with gradients of 1 per cent it was possible to carry traffic confortably with these cars.

But, in this matter, it would seem that the subject of gradients is not a very wide one.

I say once again, cars can be so built that a comparatively steep gradient can be surmounted. We do it in Austria with electric traction of which I personally have a large experience. The gradient is not then a matter of difficulty.

I fancy the remarks offered apply more to what has been so far observed; but we ought not to generalize or imagine that motor cars cannot ascend steeper gradients.

Such is the general remark I have to make, and if you will kindly allow me to quote some figures, I may say that with electric motors, with a conductor it is true (accumulators have been discarded almost universally), we have gradients as steep as 11 per cent and even 11 1/2 per cent, for instance on the Czernovitz and Pöstlingberg lines which are operated with simple adhesion.

It is, therefore, more a question of local conditions. All that can be said is that this system has not been tried on steeper gradient and we must not lose sight of this fact.

Mr. W. M. Acworth, *principal secretary.* (In French.) — In California, they have gradients of as much as 14 per cent.

The President. (In French.) — At Montreux, in Switzerland, a small town on the Lake of Geneva, there is a tiny tramway that climbs a gradient of 15 per cent without a rack, but special precautions are taken to avoid accidents.

On the Pöstlingberg line, where there is a gradient of 11 $^1/_2$ per cent for a distance of 1 $^1/_2$ kilometre (0·93 mile), special precautions have also been taken to prevent upsetting or running away on the downward journey.

Under any circumstances, that proves that lines with steep gradients can be worked trains from by simple adhesion.

Mr. J. Rostern. — I wish, Sir, you would ask delegates to mention any instances they can of railways with gradients steeper than 1 per cent that are actually worked with motors.

Mr. de Tolnay, *reporter.* (In French.) — A word in reply to Mr. Rostern's remarks. He asked a question regarding lines with steep gradients worked by automotors.

I do not know of any railways in Hungary worked by motors with steeper gradients than 1 per cent, but experiments have been carried out on the Poprád-Felka and Tátra-Lomnicz railway where there is a gradient of 1 in 28. Speed, which on the level was 50 kilometres (31 miles) fell to about 15 kilometres (9·3 miles) going up this bank.

This is the only instance I know and there a car with a de Dion and Bouton engine was used.

Mr. A. Söpkéz, Ministry of Commerce, Hungary. — I have only one observation to make in reference to the remark of our President. There is a great difference between electric traction and an automobile dealt with here. We all know that there are electric cars, running with conductors, over very steep gradients. It is possible, theoretically, to go with electric traction almost up to the limit of adhesion, and if the coefficient of adhesion is in very good weather, for instance, one-third, you can run, with electric cars, getting electric power through conductors in almost unlimited quantity, on gradients of something like 33 per cent. We have many examples of steep gradients on electric railways in Europe. I do not know the exact figures, but I believe 17 per cent and more also.

The President. — No, no, 11.

Mr. A. Söpkez. — I remember gradients of 17 or 16 per cent also, and this is quite easy to understand, because on an electric car getting power through conductors, you have as much power as you choose, and, therefore, the only limit of gradients is the adhesion. But as I said, the coefficient of adhesion varies between $^1/_3$ and $^1/_{12}$, the mean value being about $^1/_7$, it would not be practicable to go with gradients over this mean value, that is to say, over 14 per cent. But on railways, which are in operation only in the summer months, when the adhesion is generally a better one, you could overcome gradients of 33 per cent also.

There are quite different circumstances on automobiles driven with steam, benzine, etc. I will not mention that the circumference force — I believe I am using the correct term — is never equal on such engines, and depends always on the position of the piston. But, all these machines have a definite power, you could not get more power than this machine can give out, further, you can use only one part of the whole weight for adhesion, therefore the gradients cannot be so steep, as on electric railways, where the power is almost unlimited and the whole weight of the train can be used, if it is necessary, as adhesive weight.

The President. (In French.) — We are quite agreed on the subject of gradients, though there may seem to be some divergence of opinion on the point. The gradients were limited to 1 per cent, but between that and a gradient of 15 per cent, there is a large margin.

As regards adhesion, I agree with Mr. Söpkéz as to the difference there is between steam and electric traction.

Tests are now being made on the magnetisation of the rails by the return current, but as these trials are not yet completed, we cannot bring forward conclusions upon this point.

With electric traction, we have not so far used all the adhesive power that can be got with driving axles. Trains fitted with electric motors have as a rule more driving axles than trains hauled by steam power. On the Metropolitan in Vienna, experiments have been made with a train consisting of ten cars and provided with eight motors. The result has been satisfactory. As for the steam locomotive, it has only three driving axles.

The result is that with electric traction, one can obtain full adhesive power with a superabundance of driving axles, if I may so express myself.

Experiments are also going to be instituted in Vienna to use adhesion fully. We are going to place two electric motors on one axle.

As regards the gradient-limit of 1 per cent, alluded to just now, you are doubtless aware that there are lines with gradients of 3 per cent where steam traction is nevertheless employed. This is true of one international line in Austria. It is obvious, from what I have just said, that it would be possible greatly to increase the slope of 1 per cent for gradients that can be surmounted by automotor vehicles. There are in this respect some striking examples furnished by automobiles of recent build running upon roads. The number of cylinders in their engines has been increased.

There are also other considerations which must be taken into account.

This is the case for instance with a long train running on a main line, there is an enormous mass to be put in motion and a start is made with difficulty. The same is not the case when we have a small automotor train consisting of one or two vehicles. So then comparison is impossible.

I therefore come to this conclusion — and we all agreed on this point — the gradient limit of 1 per cent might be increased without any inconvenience.

Mr. John P. Ramsey, Chicago, Peoria & St. Louis Railway. — In New Mexico, on the Alamagordo & Sacramento Mountain Railroad, a road 25 miles long built for hauling timber from the mountains to the main line of the El Paso & North-Eastern Railway, they operate over a 5 per cent grade, and 30° curves, the grades being compensated for curvature. The road is in daily operation; ordinary Mogul locomotives being used — I believe the locomotives were built by the Baldwin Company. On the upper end, on what they call their logging road, they operate an 8 per cent grade, using a geared locomotive in the service, of the types known as the Shay & Heisler. This is of interest inasmuch as it is a road in actual operation with the ordinary railway equipment.

The President. (In French.) — It has just been stated that with the same locomotive running on a road, a service can be run without the slightest difficulty on lines with gradients of 8 per cent and it needs to be proved that you can travel with steam engines on lines with gradients of 5 per cent. I do not quite follow what this means.

Mr. Félix Sartiaux, French Northern Railway. (In French.) — And with curves of 30°.

The President. (In French.) — I do not understand what is meant by a curve of 30°.

Mr. John P. Ramsey. — By the English measurement, a 100 foot chord subtended by 30° at the centre; a deflection of 30° in 100 feet.

Mr. Félix Sartiaux. (In French.) — It means a fraction of circumference whose angle is 30°.

The President. (In French.) — We must take a segment having a chord of 100 feet; the angle is then given by the radii starting from the ends of the segment.

Mr. Félix Sartiaux. (In French.) — The radius would then be 191 feet.

Mr. R. Trimble, Pennsylvania Lines West of Pittsburgh. — On the lines with which I am connected, the Pennsylvania Lines West of Pittsburgh, we have some branch railroads running to limestone quarriers where we have in daily operation our regular equipment on a grade of 27 per cent, or about one in 37, and we have no difficulty at all in the operation there, and take quite large train loads over that section of railroad. Then on the Colorado Midland Railroad, between Colorado Springs and Leadville, in the Rocky Mountains in this country, they have gradients of 4 per cent, or one in 25, and there is a large traffic, passenger and freight, on that railroad.

The President. (In French.) — I suggest to the sections that we regard the subject of gradients exhausted.

We agree in recognizing that with automotors we can go much higher than 1 per cent. As I have said, all that is necessary is that they should be built to suit properly.

Mr. John P. Ramsey. — In this connection I wish to say, that in the western country a 4 per cent grade is a very ordinary one to make use of in mountain districts. The Denver & Rio Grande, one of our transcontinental roads, through the mountains operates over a 4 per cent grade. The Mexican Central out of Tampico to San Luis Potosi, operates over, I believe, a little in excess of a 4 per cent, so that on many of our main trunk lines, it is not uncommon to operate over a 4 per cent grade with ordinary motive power, that is, the regular equipment which is used on all divisions. In order to accomplish his object, an engineer will not hesitate to make use of a 4 per cent grade.

The President. (In French.) — The subject of gradients ought not to occupy our time longer. Its discussion appears to be quite exhausted.

I would beg delegates who still have remarks to make on the practice pursued on their line with light traffic, to offer us their views.

Mr. R. Trimble. — It has been suggested that I tell you, that on the main line of the Pennsylvania Railroad, crossing the Allegheny Mountains, between Altoona and Gallitzin, the grade is as much as 2 per cent, or 1 in 50.

Mr. Alexander Wilson, North Eastern Railway, Great Britain. — The great difficulty we have in England in dealing with light railways arises in consequence of the initial cost of construction. This in nearly every case of which I have had experience; has been very great. Certain obligations are imposed in regard to fencing and signalling which make the cost of construction very great, and this of course renders it difficult to secure a fair return on the expenditure. I might state that in a recent case, the Company with which I am connected took over the powers which had been obtained in connection with the construction of a light railway, but they found, on going into the matter, that the traffic which would be likely to accrue was quite insufficient to pay the interest on the expenditure, and they, therefore, decided to work the traffic by means of road motor vehicles.

Then as regards Mr. de Tolnay's remarks about the cost of working at the stations, we try, as far as possible, to limit this cost by putting on men at low wages, and by trying to concentrate the accounts at a central place, so that the accounting work may be taken away from those stations and done at that central point. I have a case in mind now where we are about to open a light railway, and we are trying to put uo low pay men at the stations, and to concentrate the accounts at a particular point so as to save expense.

The President. — If no one has anything more to say, I propose we proceed to vote upon the conclusions which run as follows :

" The simplification of the service on lines which carry little traffic has a general interest for all railways operating such lines. The present tendency of a large number of enactments to establish more liberal regulations for lines with little traffic and light trains, and the efforts of managements to equip their light traffic lines, with a more economical organization, make remarkable results possible. The simplifications introduced in maintenance of way, stations and trains, as well as the introduction of automotor cars on different lines, merit commendation.

" While recognizing that the technical side of automotor cars, as applied up to the present time, is capable of improvement, the Congress expresses the opinion that experiments with this method of transportation should be continued. "

Mr. Thonet, General Company for undertaking construction works, Italy. (In French.) — I notice that in the suggested conclusions there is no hope expressed that public administrations will encourage secondary railways by simplifying their requirements. The day before yesterday we expressed definite hopes in that direction.

I should like that in speaking of the simplifications to be introduced in operating light railways, a few words should be inserted in the conclusions with a view to pointing out distinctly that we hope public administrations will respect this wish.

Unless I am mistaken, this is a statement that has already been made.

We ought then that to state the Congress hopes public administrations will favour the introduction of some simplifications in building and operating secondary railways.

The President. (In French.) — We do say : " The Congress expresses the opinion that experiments with this method of transportation should be continued. "

This does not concern the conditions exacted by Governments from little lines.

Mr. Thonet. (In French.) — I am referring to the earlier part of the conclusions.

The President. (In French.) — Here is how the conclusions begin : " The simplification of the service on lines which carry little traffic has a general interest for all railways operating such lines. The present tendency of a large number of enactments to establish more liberal regulations for lines with little traffic and light trains, and the efforts of managements to equip their light traffic lines with a more economical organization, make remarkable results possible. "

This is a mere assertion of fact.

What you are asking for is contained in question XVIII : " Direct financial cooperation by the State and by localities interested in the development of light railways. "

We agreed that it was only right to exonerate secondary lines from taxes and grant them all possible facilities.

Be that as it may, we will try to alter the text to please Mr. Thonet.

Here is what we propose to say :

" The simplification of the service on lines which carry little traffic has a general interest for all railways operating such lines. The Congress expresses the wish that the present tendency of legislation to establish more liberal regulations for lines with little traffic and light trains, may become more general, and that the efforts of the managements to equip their light traffic lines with a more economical organization, which make remarkable results possible, be continued. "

Does that suit you?

Mr. Thonet. (In French.) — Perfectly, Sir.

The President. (In French.) — I think we are all in harmony as regards the conclusions with this amendment.

Mr. Thonet. (In French.) — Would it not be well to add at the end of the conclusions that, in view of its importance, this question should be reopened at our next session. The introduction of automotors is of so much interest that we ought to express clearly our wish to see the subject retained on our agenda paper.

The President. (In French.) — To satisfy Mr. Thonet, we might add the following at the end of our conclusions :

" It is desirable that this important question should not be lost sight of, and that the permanent Commission should incorporate it in their programme for the next meeting. "

Mr. Thonet. (In French.) — That is perfect.

The President. (In French.) — I shall now read over to you the full text of the conclusions as amended. It is as follows :

" The simplification of the service on lines which carry little traffic has a general interest for all railways operating such lines. The Congress expresses the wish that the present tendency of legislation to establish more liberal regulations for lines with little traffic and light trains, may become more general, and that the efforts of the managements to equip their light traffic lines with a more economical organization, which make remarkable results possible, be continued. The simplifications introduced in maintenance of way, stations and trains, as well as the introduction of automotor cars on different lines, merit commendation.

" While recognizing that the technical side of the question of automotors, as applied up to the present time, is capable of improvement, the Congress expresses the opinion that experiments with this method of transportation should be continued.

" It is desirable that this important question should not be lost sight of, and that the permanent Commission should incorporate it in their programme for the next meeting. "

Gentlemen, we have now considered the four questions appearing in our programme; consequently it is exhausted, and the labours of the 5th section are completed.

It now only remains for me to thank you, gentlemen, for the regular attention you have paid to our discussions.

Mr. H. Tylston Hodgson, *president of the 3rd section.* — I have to thank the members of the 3rd section for their assistance and for the interesting information they have been good enough to supply to the Congress.

— The meeting adjourned at noon.

DISCUSSION AT THE GENERAL MEETING

Meeting held on May 12, 1905 (afternoon).

Mr. Stuyvesant FISH, President, in the chair.
General Secretary : Mr. L. WEISSENBRUCH.
Associate General Secretary : Mr. W. F. ALLEN.

The President reads the

Report of the 3rd and 5th sections meeting jointly.

(See the *Daily Journal of the session*, No. 8, p. 164.)

" In Mr. Rocca's absence, Mr. de Tolnay read an abstract from the two reports presented to the sections :

" The economies to be realized in the management of railways and the simplifications which may be introduced in their operation, form a vast subject which has at all times occupied the attention of railway managers and will continue to do so. The importance of this feature is considerably greater in the case of light railways, as their moderate receipts make economy indispensable.

" Eighteen years ago, at the Milan meeting, Messrs. De Busschere and Dejaer treated the subject in detail in their report, as well as in their remarkable work which was published at the same time, and furnished an absolutely complete account of all the steps taken in this direction by different managements. Five years later, Mr. Lewis handled the subject at the St. Petersburg meeting and presented a very remarkable report, containing among other things, a collection of the legislative measures adopted by different governments, relating to light railways. The object of these legislative measures is in part to afford certain facilities for the construction of light railways, such as doing away with fencing, gates at grade crossings, etc. Certain legislative authorities also exempt light railways from taxation during a longer or shorter period. All these measures were discussed in connection with Mr. Lewis' report at St. Petersburg, and as no important changes have been made since that time in the countries with which Mr. de Tolnay is concerned, it is unnecessary to dwell too long on this point. In view of the discussions mentioned and the report of Mr. Rocca, it will suffice to mention some improvements recently introduced on the railways of Austro-Hungary, Germany and Holland.

" As regards the management proper, the tendency is to separate the service of the light railways from that of the main lines, especially as regards the officials entrusted with the maintenance of the permanent way and the operation. This tendency appears to arise from experience of the fact that light lines, to be well managed, require attention to details, which could not be expected from officials in charge of more important affairs.

" As to technical working, it may be stated as a fact, that almost all managements are satisfied to have the track inspected once or twice per day, and some of them have done away with track watchmen, replacing them with common labourers employed on maintenance work, who inspect the track in the morning on their way to work. Others entrust this task to the foremen of maintenance gangs. To simplify the station service, a great many managements restrict the passing of trains to certain stations, with a view of reducing the number and grade of employees at other stations. However, it is only at few stations that it can be arranged to prevent trains from passing each other, for, however few trains are running, the schedule will require a passing point at least every 20 kilometres (12·4 miles). To reduce the number of employees at passing points, it would be necessary to do without their cooperation in matters affecting the movements of trains; all these matters for the entire line must be concentrated in the hands of a single official. An arrangement of this kind has been in effect experimentally on one line about 60 kilometres (37 miles) long — belonging to the Hungarian State Railways — for nearly six months, without developing any disadvantages. A similar measure might overcome another difficulty encountered at small stations, *viz.* : the complexity of tariffs. An employee of limited education is scarcely qualified to understand all the rules for the application of tariffs and in addition, international tariffs are a delicate subject to handle. It might perhaps be practicable to entrust the application of tariffs to an official living at the junction station. One of the most efficient methods of reducing operating expenses will always be the reduction of the expense of traction. Now, the number of trains cannot well be reduced without causing dissatisfaction to the public or even reducing receipts. The running of mixed trains for this purpose, only partially meets the reasonable demands of the public, while the separation of freight from passenger traffic always involves some increase in the number of trains. To avoid an excessive increase in the cost of the service, the only course is to reduce the weight of the trains and the number of employees. Legislative and other measures devised for this purpose, such as doing away with brake vans, running locomotives without a special fireman, etc., were fully discussed in the papers of Messrs. De Busschere and Dejaer. There is nothing to add except the question of automotor cars, the importance of which is constantly increasing. The reporter does not think himself entitled to enter into the details of consruction. He confines himself, therefore, to mentioning some results obtained.

“ On the Wurtemberg State Railways, there were in operation in 1903, five petroleum cars of the Daimler system, seven steam cars of the Serpollet system, and one electric accumulator car. The average run of these cars was 31,717 kilometres (19,708 miles). The expense per 100 kilometres (per 100 miles) was :

“ For the Daimler car :

“ Fuel	12·06 francs	(15*s*. 6·32*d*.).
“ Lubrication	0·60 —	(0*s*. 9·27*d*.).
“ Maintenance	4·64 —	(5*s*. 11·69*d*.).
“ Total.	17·30 francs	(£1. 2*s*. 3·28*d*.).

“ For the Serpollet car :

“ Fuel	5·90 francs	(7*s*. 7·15*d*.).
“ Lubrication	0·56 —	(0*s*. 8·65*d*.).
“ Maintenance	8·91 —	(11*s*. 5·65*d*.).
“ Total.	15·37 francs	(19*s*. 9·45*d*.).

“ These results, and those obtained on different Hungarian railways, load te the hope that automotor cars will be the means of increasing the number of passenger trains without any considerable growth in cost. Still, the technical solution of this problem does not seem as yet to have been sufficiently perfected.

“ Mr. de Tolnay held that the question is not one that can be precisely answered. He, therefore, felt that no absolute conclusions should be proposed.

“ Mr. Joseph Rostern (*Great Central Railway, England*) requested that the third paragraph on page 42 of Mr. Rocca's report (1) should be corrected and the words “ Great Central Railway, ” contained in it, struck out, inasmuch as that line is not operating any train with only one man on the engine. He added that the same report omits mentioning, on page 45 (2), the automobile cars of the Great Central Railway. This company has in operation two automobiles similar to those on the Great Western, with accommodation for sixty 1st and 3rd class passengers and a small amount of baggage. He inquired whether there are any other companies, either in England or in other countries, which are using automobile cars on lines with heavy grades.

“ The President observed that the question of gradients is of comparatively minor importance, and that this difficulty may be overcome by increasing the power of automotor cars. He stated that in Austria, electric traction provides for climbing grades of as high as 11 and 11 1/2 per cent; that in California, there are gradients reaching 14 per cent, and at Montreux, on Lake Geneva, a tramway ascends, without gearing, but with special safety appliances, a 15 per cent grade.

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(1) Vide *Bulletin of the Railway Congress*, No. 12, December, 1904, p. 1878.
(2) — — — — — — — p. 1881.

" Mr. Alexander Söpkéz (*Hungarian Government*) remarked that the question of gradients differs greatly according to whether it relates to electric traction by trolley, or third rail or self propelled automobiles : with electric cars, almost the limit of adhesive power can be obtained.

" The President fully agreed with Mr. Söpkéz regarding the greater adhesion of electric vehicles, which is due, in a measure, to the elaborate driving motors with which they are equipped. He reported that experiments are about to be made in Vienna, with the object of utilizing the entire adhesion better. As for the question of the magnetization of the rail, he thought that the experiments made up to now have not been sufficiently conclusive.

" The discussion then turned to the question of the steepest grades which can be overcome by ordinary trains.

" Some instances were cited by Mr. Jno. P. Ramsey (*Chicago, Peoria & St. Louis Railway*) among the mountains of the West, and by Mr. Robert Trimble (*Pennsylvania Railroad*) among Colorado lines, where ordinary trains run on 2·7, 4 and even 5 per cent grades. These are the limits usually accepted as admissible for ordinary trains.

" Mr. Alex. Wilson (*North Eastern Railway, England*) stated that the greatest difficulties encountered in England by light railways have been the higher cost of construction and the requirements imposed on the operating companies, especially as to signal systems. The traffic has in several cases proved insufficient to pay fixed charges and cost of operation, and it has become necessary to replace the railroads with an automobile service on highways. As to the question of reducing the station service, excellent results have been obtained by utilizing lower salaried employees, doing without individual station accounts and entrusting the central accounting department with the work of the whole line. Finally, the English companies have suffered because of the requirements of the public in matters of safety. A plan for electrifying a line by means of a third rail, had to be abandoned because of complaints of the public, who claimed that grade crossings were too dangerous for the passage of cattle and the general traffic of the highway. The difficulty was met by arranging a car with a motor so that it was capable of running in either direction without turning.

Mr. Thonet (*Italian General Company for undertaking construction works*) expressed the opinion that the public authorities should favour as much as possible simplification conducive to the operation of light railways, and that this question, because of its great importance, should be placed on the programme of the next meeting of the Congress. The following draft of conclusions was adopted by the joint sections. "

The President. — The following are the

CONCLUSIONS.

" The simplification of the service on lines which carry little traffic has a general " interest for all railways operating such lines. The Congress expresses the wish " that the present tendency of legislation to establish more liberal regulations for " lines with little traffic and light trains may become more general, and that the " efforts of the managements to equip their light traffic lines with a more econom- " ical organization, which make remarkable results possible, be continued. The " simplifications introduced in maintenance of way, stations and trains, as well as " the introduction of automotor cars on different lines, merit commendation.

" While recognizing that the technical side of the question of automotors, as " applied up to the present time, is capable of improvement, the Congress expresses " the opinion that experiments with this method of transportation should be " continued.

" It is desirable that this important question should not be lost sight of, and that " the permanent Commission should incorporate it in their programme for the next " meeting. "

— These conclusions were adopted by the general meeting.

[621 .14]

QUESTION XX.

TRAFFIC CONVEYED BY AUTOMOBILES

(4th AND 5th SECTIONS JOINTLY.)

Organization of services by automotors on routes where there is not enough traffic for a railway.

Reporters :

All countries. — Messrs. Léchelle, chef du mouvement aux chemins de fer du Nord français; Eugène Sartiaux, ingénieur, chef des services électriques des chemins de fer du Nord français, and Keromnès, ingénieur principal des ateliers de machines de La Chapelle et d'Hellemmes des chemins de fer du Nord français.

QUESTION XX.

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PRELIMINARY DOCUMENTS.

Report by Messrs. Léchelle, Eugène Sartiaux and Keromnès (See the *Bulletin* of February, 1905 [2nd part], p. 855.)

Vide also the separate issue (in red cover) No. 34.

SECTIONAL DISCUSSION

(4th AND 5th SECTIONS JOINTLY.)

Meeting held on May 9, 1905 (morning).

Mr. VON LEBER, PRESIDENT OF THE 5th SECTION, IN THE CHAIR.

The President. (In French.) — Question XX is preeminently a technical question. The point is to interpose automotor trains on lines with little traffic so as to increase the traffic, especially for the conveyance of passengers.

This question is limited by the fact that the permanent way is provided for us in its present condition ; we are not supposed to provide any electric conductor.

We have then only to consider automotors driven by steam or petrol and, if we choose, automotors with electric accumulators.

These various methods of traction are dealt with in the report.

There is also another method of mixed traction which is partly electric; I mean a transformation kind with petrol.

This method of traction exists in England and Hungary; it means having a petrol motor for generating electricity and this is conveyed to the driving wheels which cause the vehicles to move.

This is the whole question we have to consider.

There was an idea of joining hands with the 2nd section to consider question VIII, but we thought it was unnecessary, as electric traction with connections is quite independent of the subject we have before us.

The subject we have to take up is then, I repeat, extremely limited.

I now call upon Mr. Félix Sartiaux who has kindly consented to summarize the report.

Mr. Félix Sartiaux, Northern of France Railway. (In French.) — In the form in which it was set, the question embraced, in a general manner, the use of automobiles in all cases where they can be used both upon rails and on roads.

The reporters have limited their investigation to services of motors on rails, serving main and local railways, exclusive of tramways. They have likewise declined to consider the employment of rail tricycles and quadricycles used for the outdoor services of companies, as well as the haulage of trains by automotors, especially electric traction by trolley, underground or third rail.

The question limited in this way is similar to the one dealt with at the Paris meeting of the Congress in 1900, when the following conclusions were passed (1) :

> The employment of vehicles, either self-propelled, or hauling trailers, has hitherto been very limited; but it appears likely to prove beneficial to develop the employment of them, so as to determine what functions they are suited to perform, not only on lines carrying little, but also on those carrying dense traffic.
>
> It is therefore desirable that railway companies should continue trials of them.
>
> The Congress expresses the hope that every simplification likely to facilitate the economical operation of these cars, may be applied to the regulations in force.

The employment of automotors on railways dates back to 1848 and as long ago as then we find attempts made with steam-carriages on main and branch lines in England, America, Switzerland, Belgium, Germany, France, Denmark and Sweden. But the subject had not come seriously before railway administrations until the few years preceding the 1900 meeting, when for the first time it was brought before the Congress where the reporters described the details of the seven automobiles in use at that time. Now they have been able to supply details of sixteen new carriages and they are at present aware of the existence of at least sixty cars of different types working in the following countries : England, Belgium, France and Algeria, Switzerland, Italy, Germany, Austro-Hungary, Servia, Russia and America.

I may further mention among the Railway Associations which have investigated this subject of employing automobiles, the German Railway Association (*Verein deutscher Eisenbahnverwaltungen*) which considered this subject at Trieste, in 1903, and the International Union of Tramways and Light Railways, to which an extremely interesting report was submitted, at Vienna, in 1904, by Mr. E. A. Ziffer, president of the Board of Administration of the Bukowina railways.

It can therefore henceforth be said that the question of the use of automobiles has grown immensely since the Congress last met, and that many experiments have been carried out.

In accordance with the sequence of the report, I shall consider :

What the types of motors and vehicles in operation are;

For what purposes these automobiles are assigned on railways and what the results of these trials have been.

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(1) Vide *Bulletin of the Railway Congress,* No. 2, February, 1902, p. 145, and *Proceedings of the sixth session* (Paris, 1900), vol. IV, p. XX-42.

PART I.

The automobiles so far used are driven either by steam, or by electricity, or by some spirit (petroleum or benzine), or by some mixed system — spirit and electricity. The working of motors by alcohol has been attempted in France and in Germany since 1900, but has not led to any good practical results.

Steam motors are a large majority. The main systems used in the most recent types of cars are the following :

In *France*, the Serpollet, Turgan and especially the Purrey systems;
In *England* and in *America*, the ordinary locomotive;
In *Belgium*, the ordinary locomotive and the Rowan system;
In *Germany*, the Thomas, Serpollet, Ganz & Co. and Gardner-Serpollet systems;
In *Austria*, the Komarek, and Göldsdorf systems;
In *Hungary*, the Serpollet, Ganz, Stolz and Dion-Bouton systems;
In *Switzerland*, the Serpollet system.

The spirit automobiles are the Daimler in Germany and in Switzerland, the Wolseley in England, the Turgan and Dion-Bouton systems in France.

Attention must likewise be drawn to a petrol car recently taken into use on the Union Pacific Railroad and built by the Jersey City Works.

Lastly, without dwelling upon electric motors, a motor driven by petrol and electricity was put into service, in 1904, on the North Eastern Railway of England. The petrol motor drives a dynamo which in its turn directly supplies the tractive power of the car.

For the time being, Is hall not compare the various systems, but consider them in a general way, both as regards tractive power and traffic, in the latter part of this summary.

The cars are supported on four wheel bogies in England and in America and, in some cases, in Germany and in Hungary; but most of the other cars, especially the bulk of those working in France, have two axles. Their length over all varies between 9·145 metres and 26·21 metres (between 30 and 86 feet); they accommodate from 15 to 100 passengers.

I may pass over the other details which appear in the report.

PART II.

I shall first consider the class of services done by these automobiles. Their purpose is to work the lines which may fall into one or other of the two following classes :

1. Secondary lines on which the number of would-be passengers is small enough to make it advantageous to substitute one automotor for the ordinary trains, or

when, owing to the lower cost per car-kilometre, it be decided to increase the number of trains in the hopes of increasing the number of passengers;

2. On main lines, either to accommodate a suburban service where the traffic is not heavy enough to be economically served by ordinary trains, even if light ones, thus supplementing the principal service at times of days when the traffic is light; or to replace the service of stopping trains throughout a busy section or between two important places, the ordinary trains running a fast through service and the automobiles acting as collecting and distributing trains interspersed between the through trains.

I pass over the paragraphs which deal with the amount of traffic that can be conveyed, the weight and speed of the cars, as details upon these points are given in the report and I come straightway to the subject of cost.

I must first lay stress on the fact that any comparison between the cost of motors in different countries has no more than a quite relative value. For this cost depends on a series of factors : wages of staff, cost of fuel (coal, petrol, etc.), the divisor of the daily expenses and the number of kilometres run *per diem;* these are too slightly comparable for anyone to be able to derive accurate information therefrom.

The comparison really is of no value except between the cost per automotor and the cost per ordinary train in similar service under the same administration, for data can only be compared with some accuracy in a single country and under similar economical and technical circumstances.

In their paper the reporters have given all the figures of this kird that are comparable whenever they could get them and I trust the sections will be good enough to refer to them.

Despits the very restricted number of results that I have been able to collect, I think I can summarize them by stating that when the employment of automotors is practicable and justified, it means a real saving in the ordinary service of even light trains owing to :

1° The reduction in the number of drivers to a single one;

2° The decrease in cost of traction per kilometre;

3° The reduction in cost of maintenance, though this latter point is less clearly proved than the two first.

Moreover, the use of automotors involves indirect saving, such as that arising from a better utilisation of the rolling-stock and the smaller extent of station equipment required. That the car can be used in both directions, without turning round, possesses obvious advantages.

To conclude in a general manner, I may state that instances of using automobiles on rails have multiplied since the Congress last met, and have attracted the attention of a large number of railway administrations.

Of all the cars in use, the electric ones have proved least successful.

The various types of petrol motor have met with some favour, but the system far the most employed, is the steam motor of different patterns.

Without desiring to enter into any detailed comparison of these various methods of traction, it may be stated that the steam motors possess the advantage of being more powerful and consequently the most economical, and they allow of more regular working; they possess, however, the disadvantages of starting and stopping less quickly than spirit motors, of the motor being heavier in proportion to its adhesive weight and, in the case of some of them, such as the Serpollet and Rowan cars, of having their controlling and valve gear exposed to bad weather and dust.

The disadvantage of spirit-driven cars is that the machinery is delicate and that much power in lost in the gearing; moreover, they vibrate uncomfortably at starting and stopping; but they are easy to drive and the driver can, during running, concentrate all his attention upon the speed, the track, the signals, etc. These cars can be more easily run in both directions without being turned, and from the date supplied, the cost of their maintenance is lower than in the case of the engines driven by steam.

As regards accumulator cars, their great disadvantage lies in the enormous dead weight, and in the limitation of power which is that of the quantity of electricity stored.

Such are the various points that have attracted the attention of the reporters. Among them there is, for instance, the superlative question of cost, about which these data are still very insufficient; to these I draw the special attention of the sections in the hopes of getting more accurate and more extensive information. It has not been found practicable to consider other points of minor detail, or it has not been possible to discuss them except in a very summary manner, such as the comparative advantage of automotors used separately or with a trailer, reductions of fares likely to develop this method of working and any simplifications of the byelaws in force tending to facilitate the economical employment of these cars.

The President. (In French.) — I hope any delegates who are interested in this subject and who are in a position to offer us information on the subject, will kindly speak. This matter is of sufficient interest to merit attention from all delegates and we shall derive much pleasure from receiving any additional data.

Mr. Laurent, Paris-Orleans Railway. (In French.) — Gentlemen, the Orleans Company to which I belong, has for a long time past taken an interest in the subject of motor cars for all the reasons that the reporter has so clearly and fully indicated.

I am going to give you a short account of the attempts made by my company to use automotors since 1903, the date when a first motor car was experimentally started.

The object with which we set out upon this experiment was to meet a special requirement on a given line. Our scheme was as follows : to substitute on a line with little traffic for a " light " train an automotor train consisting of the automotor vehicle and one or two 15-ton trailers, capable of running 20 kilometres (12·4 miles) an hour up a gradient of 20 per mil at 60 kilometres (37·3 miles) an hour on the level.

The object of the experiment was also to see what such a train cost with a view to further applications.

To carry out what we wanted, meant a motor car with about 130 horse-power. It was realized that, for such a power, the use of a boiler of the locomotive type would be hardly advantageous and that the solution of the problem would lie in the use of a steam boiler with water tubes.

Our choice fell upon the Purrey boiler, which in France was sanctioned by the light of experience, for it had been used with success for some time on the tram-lines inside Paris.

The motor car built and put into service in 1903, was a four wheeled car weighing about 20 tons and comprising, besides the boiler situated in front and the motor lying under the floor, a luggage compartment with an area of 10 square metres (108 square feet), a compartment for mails, seating accommodation for 26 persons and a platform.

This car was capable of hauling two 3rd class carriages with four compartments.

We have carried out a certain number of experiments with this car.

The motor car with its motor and its boiler of about 130 horse-power has given us satisfaction. We have carefully watched the services it has rendered during about a year and a half both as regards the net cost of traction and the saving effected compared with running a " light " train. It is not possible to quote exact and quite conclusive figures as regards the cost per train-kilometre, because a number of drawings to scale have been necessary and the data we possess ought to be checked by longer experience; but the results have been sufficiently satisfactory and the trials sufficiently encouraging to decide the Orleans Company to continue them further. We have ten more motor cars of a similar pattern and of about 200 horse-power being built.

These cars differ a little from the original one. We have deemed it preferable to have cars with a bogie-motor carrying the boiler and the motor and with a car carried in front on the bogie-motor and behind by a pair of wheels.

This arrangement seemed likely to make it easier to negotiate curves. It likewise rendered it possible to avoid keeping complete spare trucks. For ten cars, we shall need only two spare trucks and as these trucks carry the boiler and the motor — when we have to take off the motor trucks for the repairs requisite for the boiler and the motor — we shall only have to put in front of the car a new truck and our car will not be standing idle.

So our motor comprises a motor truck with a van carriage supported on this truck. We carry a good deal of luggage and so we have had to provide a van 10 metres square (108 square feet). Our car will have seating accommodation for

55 people, two and a half 1st class compartments and three 3rd class compartments. Moreover, these motor cars will be able to haul an ordinary car accommodating 90 persons.

These cars are on order and due to be delivered soon. They will be used either to take the place of trains already being run on lines with little traffic, or to put on new trains upon these same lines. They will likewise be used on more important lines to run new stopping trains which will be run at higher speeds than the existing trains, or again we may introduce new stopping trains which will enable us to convert some others into expresses on certain lines and for these the automotor train will do to pick up passengers.

In short, this is the programme Mr. Sartiaux recently sketched out for us, and we shall be able to realize it in the new more extensive trial we are, I hope, going to undertake by the end of this year.

Our intentions are not yet fixed; we do not regard the problem as by any means solved; we know there are many points to be cleared up as regards maintenance, and how the motors will behave when they are working and when we have enough of them. It will have to be seen what will happen with the boilers. These are not so easy to inspect as our locomotive boilers which are so convenient and so manageable. It will be necessary to take great care of them; we have already experienced difficulties in this respect; very pure water must be used, constant supervision is required so as to take out any tubes that get furred in plenty of time to avoid a break-down.

But, though we may not have reached absolutely definite conclusions, we have received sufficient encouragement to proceed further. That is the precise position of the question.

I may say that one special technical point about our car is that it is driven by a chain. At first we were somewhat afraid about this chain taking the place of our usual rods. But we have had no trouble whatever with it. The chain has been in use upon the motor car we have been employing for more than a year a half and has given no trouble; we have therefore adhered to this method of chain driving for the ten motor cars that we have in order.

The President. (In French.) — Could you tell us a little about the speed and the cost price?

Mr. Laurent. (In French.) — We expect to be able to run, over undulating lines with gradients of as much as 15 to 20 per mil, with one trailer, trains at what we call a standard speed of 60 kilometres (37·3 miles), that is to say, a speed varying from 45 kilometres (28 miles) an hour on the steepest gradients to 65 kilometres (40·4 miles) on the level. On lines that are easier and with the car alone, we shall be able to have trains running at 80 kilometres (49·7 miles). This is what we are allowing for. I think I can say that, with our experience of the car we are running, we do not anticipate that there will be any trouble in realising this estimate.

Mr. De Lannoy, Flanders Western Railway, Belgium. (In French.) — I had no intention of speaking to-day, but I think it may be useful if I tell you that for the last ten years at least we have been using steam cars. These steam cars represent 12 per cent of our stock, that is to say there are 7 out of 58 locomotives.

These steam cars belong to the pattern of the old Belgian Belpaire ones of different patterns more or less modified, and they have boilers of locomotive type. The boilers are tested up to 10 atmospheres; the motors are 100 horse-pover. The trials we have made during the last ten years have not been highly successful, I must admit. Now that these locomotives are beginning to get old, we have found that they need a lot of repairs to the machinery which is too light, and moreover because of the crank axles which break rather frequently. On some of the cars, two axles are coupled, while on others there is only one driving axle and a radial axle.

They can accommodate altogether 50 1st, 2nd and 3rd class passengers and there is a compartment for luggage; the ones with two axles coupled can take one trailer weighing 8 or 9 tons.

As regards economy, we find hardly any saving. As a rule, there is a driver, a fireman and a guard, so that there is only one hand less than on an ordinary train.

As regards coal consumption, it is about half what is necessary for the ordinary trains. As for repairs, I believe they cost more than on our locomotives. In my opinion, according to our actual experience, the motors of these cars are too often undergoing repair, which means leaving the cars standing idle. Under these circumstances, I should not be at all disposed to purchase any new engines of this class, and I should give up experimenting with these motor cars because our experience has not been brilliant.

Passengers complain much of these carriages on account of the abnormal vibrations which arise from two different causes: first, those due to the strokes of the pistons which are felt directly in the carriages; secondly, there is the great length of the carriage; the radial axle being alone at the end, there is the oscillating vertical vibration which is also very disagreeable for passengers.

I did not intend to speak, but I thought it only right to tell you what experience we had gained during the ten years we have using steam cars.

The President. — Are there any English gentlemen present who will give us some details about the experiments with automobiles in England?

This subject has already been discussed to some extent in the 5th section. They told us there that the main lines took no care at all of light railways, and that when such light railways had to be constructed, they had to bear the whole expense for what it is necessary to have. In England, light railways are needed, but it is difficult to have them provided; it would be a very useful thing if the English members of the meeting would tell us what experiments they have made up to the present day in their country.

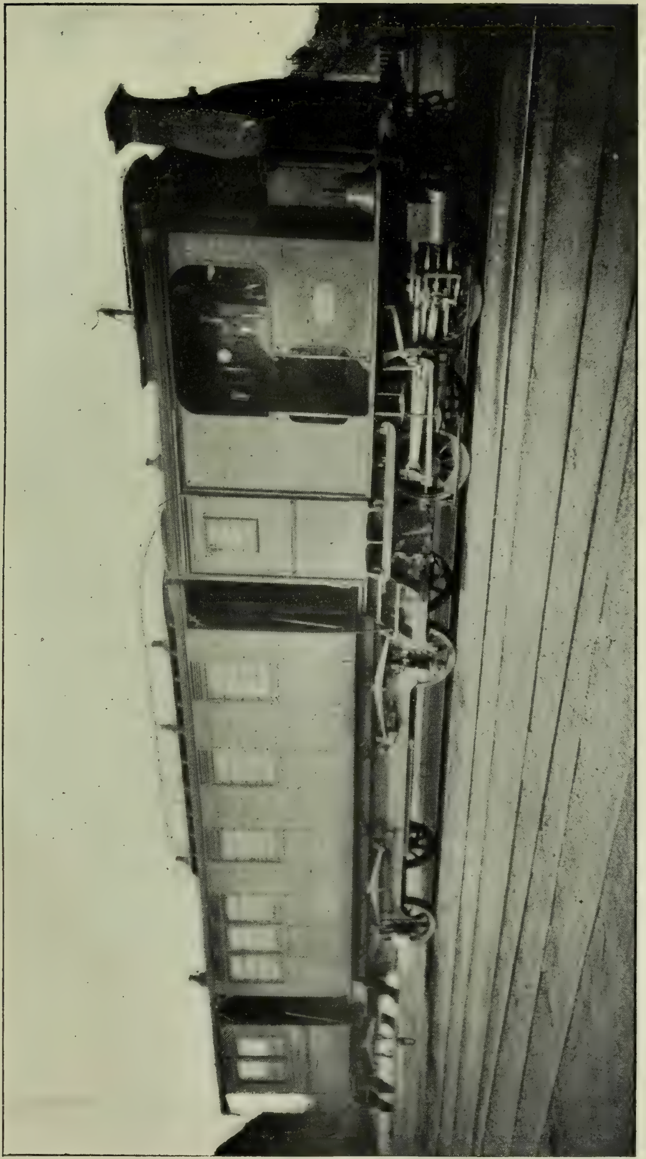

Fig. 1. — Steam car with two coupled axles. — Flanders Western Railway Company (Belgium).

Mr. E. L. Davis, North Eastern Railway, Great Britain. — Gentlemen, I can give you a little information with regard to the experiments which the North Eastern Railway Company has been making with the type of motor described in this pamphlet. The work so far we regard as experimental. We put two vehicles of this described type into service last summer on a branch line, and during the ninety-six days of operation we felt on the whole satisfied with the results — although we had several of those instances which always occur in new undertakings, that is failures of the machinery — satisfied and pleased at the results. The net result was this. That whilst during the ninety-six days, the gross receipts per car-mile worked were but 14·59 pence, the working expenses were at the rate of about 5·209 pence per mile, so that there was a satisfactory balance in favour of the experiment. We ran during those ninety-six days a total mileage of 11,500 miles. Then, during the winter months, we have continued working these cars on another part of the line where the gradient is a little more severe, and I should say that we find the principal defect of the cars is that at present the motor is not sufficiently powered. It runs very nicely on the level, or on a gradient that does not exceed 1 per cent, but when you get to a more severe gradient the power is not sufficient for the purpose. Of course that is something which can be improved in later constructed cars.

The great advantage we see, is that the car is very economical in working. It only requires two men instead of three; it is available for use at 10 minutes notice, and on a level it will run at a speed of 36 miles an hour; also it can carry sufficient fuel and water for an ordinary day's run, say for something like 60 miles, and what is particularly noticeable is the steadiness of the drive; there is none of that vibration which has been spoken of, you can feel nothing like the motion you do in the case of that which is created by the piston on steam trains. With this car it is a continuous, steady, smooth pull.

I may say that the conclusions suggested by this report on page 36 (1) seem to me to be right. I would suggest that in No. 1 the word " precious " would be better if changed to " valuable ".

I should be very glad, without taking up any more time of this session, to give any information I can at any time with regard to these coaches, to any delegates who are interested in the subjetc.

Mr. W. W. Hoy, Central South Africa Government Railways. — Mr. Chairman, I wish to speak rather on the functions which the service I represent expects from the motor car, than from actual experience. The steam motor car was introduced upon the Cape Government railways in South Africa, more than ten years ago, but the expectation of the officials was then not quite realized. The experiment was premature.

Since that time the growth of towns and the opening up of the country has, in the opinion of the officers, presented an opportunity for experimenting again. Steam motor cars have now been sent to South Africa, and are being introduced on the railways. I cannot speak of actual comparative costs, but the estimate framed corresponds nearly to that stated by Mr. Davis. We expect that the cost per train-mile will be in the neighbourhood of 7 pence. We propose to use these cars in connection with what I should prefer to call light branch railways, not necessarily meaning narrow gauge railways, but rather a railway of the standard gauge lightly constructed both in a permanent way and in rails. Our idea is to run these cars daily, probably on the less busy lines twice or three times per week, and by their employment we shall economically operate the lines and run goods trains only when actually required, and thereby we hope to reduce materially the train mileage, in connection with our goods traffic, over the lines where it does not pay, and it is still necessary to maintain a fairly regular service to and from even some minor districts. By adopting these cars, and running goods trains only when necessary, we hope to effect considerable economy.

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(1) Vide *Bulletin of the Railway Congress*, No. 3, February, 1905 (2nd part), p. 888.

The cars ordered are to convey 1st and 2nd class passengers and also possess a compartment for baggage. The locomotive engineer who designed them hoped to be able to allow a light trailer to be hauled with that car.

I do not think, gentlemen, I can add more to the discussion, but I thought it might be interesting to know what is being done and the improvements which we have in view. (*Applause.*)

Mr. Y. Kinoshita, Ministry of Communications, Japan. — May I ask one question of Mr. Davis and Mr. Hoy? We are very much interested in the experiments with motor cars as given by these two gentlemen, and I shall be very happy if I could hear from Mr. Davis and Mr. Hoy what is the price of those motor cars, and also the capacity of those cars.

Mr. E. L. Davis. — The seating capacity of each car is 52; the cost of each car has been very much above the normal cost because before they were put in operation we were experimenting for a good many months, and had to make various alterations and repairs, and generally put them into working order; of course the cost of the first two cars cannot be taken as any criterion of the cost of similar cars hereafter. The total cost of the first two cars, as a matter of fact, was £7,000.

Mr. W. W. Hoy. — The cost of the cars under order for my administration is £3,000 each landed in South Africa. They would carry 40 2nd class passengers and 20 or 25 1st class passengers. I am speaking from memory, I am not very sure; but I know the total figure is about 60 or 65 passengers. There is a baggage compartment on them. They are expected to attain a speed of 30 miles an hour. The gauge is 3 ft. 6 in. I should add that £3,000 of course includes freight by sea.

Mr. Laurent. (In French.) — In France, the car of which I spoke as accommodating 55 passengers and capable to travelling at a speed of 80 kilometres (49·7 miles) an hour on the level, will cost between 35,000 and 40,000 francs (between £1,400 and £1,600).

Mr. W. H. Hyde, Great Eastern Railway, Great Britain. — Mr. Chairman, nothing has been said so far as I can find in regard to road motors in connection with this question. Am I in order in speaking on that?

The President. — Yes. Although that is not comprised in the question before us, if you have some interesting matter to tell the sections, we shall be glad to hear it.

Mr. W. H. Hyde. — With your permission, then, I will give one or two particulars in regard to our own, the Great Eastern Railway. We have not adopted the rail motors because we do not think they are suitable for our kind of traffic, but we have experimented with the road motors in connection with our railway.

A little over a year ago, we put three on the road in one of our districts, and we were well satisfied with the results. The summer receipts were larger than during the rest of the year, but we anticipated that. But taking all the year with the expenses and allowing for depreciation — which is a very necessary thing — allowing ten years to wipe out the life of a car, and also allowing for the tires, which are always a heavy expense, we are satisfied with the results of our experiments. They will prove a feeder to the line, as they have already done. The cars convey passengers only, each carrying 36 people, but we are now building ten other cars, some to be passenger cars only and some to be goods and passenger combined, and these we are about to put on the various districts in connection with the lines to open up places where it would not be possible to put a railway. I think that is all I can say in regard to that.

With regard to the rail motor experiment, may I ask Mr. Davis a question. He says his expenses are 5·209 pence a mile. What does that cover; does it cover anything for repairs and depreciation and so on?

Mr. E. L. Davis. — It covers everything.

Mr. Thonet, Italian General Company for undertaking construction works. (In French.) — I should like to get a piece of information from Mr. De Lannoy. He has spoken unfavourably of his experience with Belpaire automotors. It would seem that the experience extends over ten years.

It would be interesting to hear whether the West Flanders Railway Company intends to try new automotor cars, of the Purrey or other pattern, because if we get comparative results in a few years, assuredly the company that has encountered difficulties in using the Belpaire automotors will be in the best position to give us the most convincing data.

Those who are interested in the subject, ought to have an opportunity of observing the experiments that are to be carried out. Our colleagues from other countries will even if necessary be able to visit Belgium to investigate on the spot whether the tests are being conducted on a large scale.

The President. (In French.) — That would be all the more suitable because there are differences in the construction of the boilers; these have been alluded to by the Orleans Company.

Mr. Thonet. (In French.)— We have had one criticism that is unfavourable, but the general view seems to be that we ought to use automotors with the proviso that we must endeavour to introduce improvements. But some companies might hesitate to begin using automotors in view of what Mr. De Lannoy has stated.

Mr. De Lannoy. (In French.) — We have gradually altered the cars with a view to improving the system; but our attempts have hardly proved successful and we do not think ourselves justified in going on with them.

I believe it is only right to give up trying steam cars; I prefer small engines with light trains, which do not cost more than steam cars and are easier to maintain and work.

Mention has recently been made of high speeds. Now, in the case of the steam cars we have fixed the limit at 30 kilometres (18·6 miles) an hour — average speed including stops. That is not very high, and yet sometimes we find it difficult to keep up this speed. Moreover, even with this low speed, wear and tear and the costs of repairs are considerable.

I have had an opportunity of using another pattern, the Rowan system, which is widely known; the subject cropped up at the Paris meeting in 1900, but this type had to be given up also after a short time, because the boiler was not strong enough.

They were first tried on some undulating lines and then on some fairly level lines, but the results were not good.

I was told by the Belgian Light Railway Company that they had to give up these cars too.

Mr. E. A. Clear, Great Central Railway, Great Britain. — Mr. Chairman and gentlemen, I think, for the information of our Continental and American friends, it should be stated in a general way that motor cars for the conveyance of passengers on branch lines are being used in England to a somewhat larger extent than in other countries.

The London & South Western Railway is working steam motor vehicles in the South of England. The Great Western Company is using them near London, in North Wales, and in other places. In the latter company's last half-yearly report, some very interesting figures were given with regard to the traffic worked by motor cars, and the chairman of the line stated satisfactory results had been realised.

The Great Northern Company also use a car on their Hertford Branch Line, but this is worked by a petrol engine.

On the Great Central Railway, which I represent, we work a steam car on the branch lines in North Wales. It was put into working at the beginning of this year, but I could not give you any idea what it has done for us up to the present time. We hope, if it gives satisfaction, to make use of motor train services in the agricultural districts of Lincolnshire.

In addition to these, I should like to state that motor road cars are being extensively used in England, as feeders to the main lines. The Great Western Company has nearly 40 such cars in working, I believe.

A member. — Eighty!

Mr. E. A. Clear. I am not undertaking to speak for any Great Western gentleman here. I do not see anyone from that railway at this meeting, and I can only speak of the general situation as I know it, but I am pleased to find I am under the mark.

The Midland Company uses a petrol vehicle for the conveyance of parcels, and the Great Eastern, and Great Central Companies do the same.

The Great Central Company also employ petrol and steam driven vehicles for the conveyance of goods traffic, and as I am connected with that department, I can tell you that after eight months experience we find petrol motor vehicles give the best results. The average tonnage conveyed by each vehicle per journey is 4 tons 18 cwts. We work them for the first five days in the week and on the Saturdays they are put up for a thorough overhauling, as it is necessary to efficient working the machines should be kept in good order.

We consider the vehicles are being worked at half the cost of horse traction, and we are so convinced of their utility, that we are giving orders for other vehicles, (*Applause.*)

Mr. John Pickering, South Australia Government Railways. — Mr. Chairman and gentlemen, I have no technical knowledge with reference to this question, and I should hesitate to speak about it only that the chairman has encouraged those who have any knowledge as to facts to give them; that is why I venture to make a few remarks.

I am from one of the smallest States of Australia, but as we have had some experience in steam motors and we are stepping out in another direction, I thought it would not be amiss simply for me to give you our experience. It is somewhat of a unique experience with reference to the character of country and the population. You are all railroad men and you will realize what difficulties we have when I tell you that we have 1,200 miles of continuous main line from the south to the north in South Australia, 1,200 miles running through a country with a population for the State altogether of only 365,000. Part of that, one-third of it, is probably found in the central city, the capital. So this 1,200 miles extends through a territory, apart from the capital, that perhaps has only 100,000 inhabitants. We are expected to make those lines pay. You see the difficulty. We are realizing that we can only make them pay by having vehicles, automobiles, suitable for carrying very small numbers of passengers instead of having locomotives and trains in the usual way. We tried some twelve years ago with the steam motors, and we realize as has been mentioned this morning, that owing to the smoke and the motion of the steam motor and the constant repairs necessary, it is unsatisfactory. We are using now the gasoline inspection cars on the line and we are saving considerably with those, and we have ordered some cars carrying I think about 30 passengers and travelling from 20 to 30 miles an hour. That is a first order of two or three of them. We intend introducing them on our lines with a sparse population, realizing that that is the only way we can expect to pay our way, operating expenses and interest on capital. We can do it, because we have heavy mineral traffic in some other parts of the State, but if it were dependent on this 1,100 or 1,200 miles of line, working the ordinary way for railways, we could not possibly hope to do anything of the kind. (*Applause.*)

I think I ought to add, in explanation, that this motor car I speak about would be used, of course, not for the 1,100 or 1,200 miles continuously, but only for those portions of the road where the traffic is exceptionally light.

The President. (In French.) — Are you all prepared to vote upon the reporter's conclusions?

Only one member of the section has referred to difficulties in carrying out experiments in this direction, but perhaps I ought to add that the first speaker to whom we listened, a delegate from the Orleans Company, stated that the trials made were not crowned with success, because of difficulties with the boilers. Alterations were effected. The boilers first used were exactly like those of locomotives with smoke tubes and not water tubes.

The new boiler is a vertical one with water tubes; that is an entirely different matter. Again, there are other improvements we can refer to. It may, therefore, be imagined that the bad results obtained in a single case are rather exceptional. I believe most of the members of the 4th and 5th sections will agree to accept the conclusions in the report. If no objection is raised, I propose to read you these conclusions in French and in English.

Allow me to make one remark on this point.

The conclusions at the end of the report are very general and a trifle brief. I think we might amplify them. I notice that before the conclusions in the report, there is a summary in which the reporters have strung together what they found to be most general and of most note. We might take a portion of this which appears on page 35 (1).

It does not appear doubtful that, owing to the saving of an employee in the driving, to the material reduction in the cost of traction, to the probable reduction in the cost of maintenance, to a better utilization of the rolling stock, to the smaller extent of station installations required, perhaps also owing to less wear of the rails, automobile and automotor cars will make it possible materially to reduce the cost of working lines with little traffic and will in the cases of other lines result in a material improvement in the working of some classes of service. Their use will certainly effect a change in the system of operation in the case of a great number of lines and appears to have a real future before it.

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(1) Vide *Bulletin of the Railway Congress*, No. 3, February, 1905 (2nd part), p. 887.

The period of actual operation has, however, only just begun, and definite economic results cannot yet be clearly discerned in favour of a given type of motor or of a given systemof working.

We might insert this passage between the first and second conclusions.

I will now, if you will allow me, read you the proposed conclusions in full.

" 1° Experiments with automobile cars and with automotors hauling trailers have been numerous during the last few years to an important extent, both for use on lines with little traffic and for use on busy lines, and it may be expected that, from henceforth these cars will constitute a valuable means of transportation, which on some lines will have a great future.

" It does not appear doubtful that, owing to the saving of an employee in the driving, to the material reduction in the cost of traction, to the probable reduction in the cost of maintenance, to a better utilization of the rolling stock, to the smaller extent of station installations required, perhaps also owing to less wear of the rails, automobile and automotor cars will make it possible materially to reduce the cost of working lines with little traffic, and will in the cases of other lines result in a material improvement in the working of some classes of service. Their use will certainly effect a change in the system of operation in the case of a great number of lines and appears to have a real future before it.

" The period of actual operation has, however, only just begun and definite economic results cannot yet be clearly discerned in favour of a given type of motor or of a given system of working.

" 2° It is desirable that railway managements should continue their experiments in this direction, and more especially investigate the classes of service to which this new motor is suitable, and the advantages it offers to the public and to the railway managements, particularly in the matter of cost.

" 3° Finally, it is important that any changes recognized or which may be hereafter recognized, as likely to facilitate the advantageous use of automobile and automotor cars, should be introduced into the regulations in force. "

If no objection is raised, I shall put these conclusions to the meeting.

— The conclusions were adopted *nem. con.*

— The meeting then adjourned.

DISCUSSION AT THE GENERAL MEETING

Meeting held on May 12, 1905 (afternoon).

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MR. STUYVESANT FISH, PRESIDENT, IN THE CHAIR.

GENERAL SECRETARY : MR. L. WEISSENBRUCH.

ASSOCIATE GENERAL SECRETARY : MR. W. F. ALLEN.

The President read the

Report of the 4th and 5th sections meeting jointly.

(See the *Daily Journal of the session*, No. 8, p. 166.)

" A single report was prepared on this question; it was summarized before the 4th and 5th sections by Mr. F. SARTIAUX (*Northern Railway of France*).

" The reporters, like those who dealt with the subject at the Congress of 1900 at Paris, on the same question, but with more examples at their disposal, confined themselves to considering the employment of vehicles on rails, for working traffic on railways only, not considering tramways.

" Mr. F. Sartiaux first enumerated the types of vehicles employed, indicating the special development of steam motor cars, which appear to be more highly approved than petroleum, electric or mixed vehicles. He stated the range of sizes and capacity of the vehicles.

" He then passed to an examination of the services to which automobile vehicles can be applied. They may be used :

" 1° On secondary lines, on which the number of passengers is sufficiently small to make it advantageous to replace ordinary trains by automobile cars, or, owing to the lower cost per car kilometre, in cases where it is desired io increase the number of trains with the hope of increasing the number of passengers;

" 2° On main lines, either to accommodate a suburban service, where the traffic is not sufficient to be carried economically even by light trains; or as supplementary to the principal service, at hours when there is little traffic, or also as replacing the service of " omnibus " trains from both sides of a central point or between two important stations, the regular trains furnishing a rapid through service and the automobile cars acting as collecting and distributing trains running between the through trains.

" Then passing to the question of the cost of automobile service, Mr. F. Sartiaux thought himself justified in concluding, notwithstanding the limited number of results reached up to this time, that the use of automobiles affords a real economy over the ordinary service of even light trains, for these reasons : 1° the saving of one employee in the driving; 2° the reduction in the cost of traction per kilometre; 3° the reduction of the cost of maintenance, this third point being less clearly demonstrated than the other two. It is necessary also to consider the indirect saving effected by the better utilization of the rolling stock, the smaller extent of station installations required and the ease of running in either direction without turning around.

" In conclusion, he compared briefly the three leading systems of automobile cars. Steam cars are generally more powerful and more economical than the others; but they do not start as quickly as petroleum cars and they are heavier. Petroleum cars have the disadvantage of containing delicate mechanism and gearing, causing a serious loss of power; they also have a disagreeable vibration when starting, but it is easier to drive them and the cost of maintenance appears to be lower than that of steam cars. As for storage battery cars, the objection to them is the great amount of dead weight and their limited power.

" Mr. T. F. LAURENT (*Orleans Railway*) gave an account of the experience of the Orleans Company with automotor cars since 1903, when the first one was put in operation as an experiment. This car was designed with the following object : to replace an existing light train on a light railway with an automobile train consisting of one automotor car and one or two trailers, capable of developing a speed of 20 kilometres (12·4 miles) per hour on a 2 per cent grade, and 60 kilometres (37·3 miles) per hour on level sections. The object of the test was also to ascertain the net cost of such a train, with a view to more extensive application. To make this test, it was necessary to have a motor car with a capacity of about 130 horsepower. It was realized that for this power it would not be advantageous to employ a boiler of the locomotive type, and that to solve the problem a water tube boiler should be used. The preference was given to the Purrey type of boiler, which had been used successfully for some time on street railway lines in Paris. The automotor car built and put in operation in 1903 was a car with two axles, weighing about 20 metric tons, which in addition to the boiler located in front, and the motor hung under the floor, included a baggage car with 10 square metres (108 square feet) of floor surface, a compartment for mails, seats for 26 passengers and a platform. This car can draw two 3rd class trailers with four compartments. It has been running about a year and a half, and although it is not yet possible to give exact figures on the cost per train-kilometre, owing to the many readjustments that have been necessary, the results have been sufficiently satisfactory to induce the Orleans Company to continue the trial on a larger scale.

" The company has at present under construction ten automobile cars of a similar type, of about 200 horse-power. These cars will consist of a motor truck carrying the boiler and motor, and a carriage supported in front by the motor truck and by an axle in the rear. The car includes a baggage car of 10 square metres (108 square feet), two and one-half compartments of the 1st class and three of the 3rd; 55 seats in all. It can draw at a speed of 65 kilometres (40·4 miles) per hour on the level and 45 kilometres (28 miles) on a grade of 2 per cent, a passenger car containing 90 seats. It can run alone at a speed of 80 kilometres (49·7 miles) per hour on a level.

" The company has decided to use these ten cars, either to replace existing light traffic trains by automotor trains, to furnish new services on the same line, or to establish, on lines with heavy traffic, services which would enable certain stops of local trains to be omitted and thus increase their speed. The automotor trains would then be used in some places as collecting trains. These cars will be in operation at the end of the present year.

" As interesting technical information, Mr. Laurent reported that the wheels are driven in these cars not by driving rods, but by chains. At the beginning, the engineers of the company were somewhat afraid of the working of the chains, but during the whole period of the experiment, no difficulties were noticed. The use of chain driving as well as a good balancing of the motor, which is placed under the car between the frames, affords reason for the expectation that there will be no trouble in these cars from vibrations which have sometimes made traveling in automotor cars disagreeable to passengers.

" It is difficult, he stated, to give as yet the precise results of the experiments of the Orleans Company, but that the latter expects that after the experiments which are being conducted at present on a larger scale are completed, it will be able to estimate the value of this new method of operation.

" Mr. De Lannoy (*Flanders Western Railway, Belgium*) reported trials made on his system for ten years past with automobile cars with boilers of the locomotive type. The trials have not given satisfactory results because of the numerous heavy repairs required by this kind of machine. The economies realized in the number of employees and in fuel consumption have been more than offset by the extra expenses of maintenance.

" Mr. E. L. Davis (*North Eastern Railway, England*) supplied interesting information concerning trials with automobile cars made on his road. The gross receipts per train-mile were 14·59 pence. The cost of traction was 5·209 pence and the net receipts 9·29 pence.

" Mr. W. W. Hoy (*Central South Africa Government Railways*) said that some experiments there of this kind during the last ten years have led to good results. The automotor cars are used under the same conditions as those previously described. In South Africa especially, there are light railways serving mining districts on which a regular train service would not pay, but where the use of automobile cars for passengers has given full satisfaction. It is his opinion that this success can be obtained as well on narrow gauge as on standard gauge lines.

" In reply to a question put by Mr. Kinoshita (*Japanese Government*) regarding the number of seats and the cost of automobile cars, Messrs. E. L. Davis, W. W. Hoy and Laurent gave the following information : On their lines, the number of seats to a car is respectively 52, 65 and 55; cost of the cars is approximately £3,500, £3,000 and 35,000 francs (£1,400).

" Mr. W. H. Hyde (*Great Eastern Railway, England*) and Mr. E. A. Clear (*Great Central Railway, England*) broached the subject of the use of motor cars on highways, which may aid in increasing passenger traffic. The president, Mr. von Leber, remarked that this method of transportation did not come within the province of question XX.

" Finally, Mr. John Pickering (*South Australia Government Railways*) expressed the opinion that certain sections of the main line of his system, with a length of 1,200 miles to 365,000 inhabitants, which passes through a new and sparsely populated country, could not be operated at a profit except with automotor cars.

" The president, Mr. von Leber, referring to the practically identical views expressed by the speakers in regard to the use of automobile cars of carefully selected types as used in special kinds of service, submitted to the sections the following proposed conclusions, the wording of which was taken from the reporter's paper and was unanimously adopted. "

The President. — The following are the

CONCLUSIONS.

" 1° Experiments with automobile cars and with automotors hauling trailers " have been numerous during the last few years to an important extent, both for " use on lines with little traffic and for use on busy lines, and it may be expected " that, from henceforth these cars will constitute a valuable means of transporta" tion, which on some lines will have a great future.

" It does not appear doubtful that, owing to the saving of an employee in the " driving, to the material reduction in the cost of traction, to the probable reduc" tion in the cost of maintenance, to a better utilization of the rolling stock, to the " smaller extent of station installations required, perhaps also owing to less wear " of the rails, automobile and automotor cars will make it possible materially to

" reduce the cost of working lines with little traffic and will in the cases of other
" lines result in a material improvement in the working of some classes of service.
" Their use will certainly effect a change in the system of operation in the case of a
" great number of lines and appears to have a real future before it.

" The period of actual operation has, however, only just begun and definite eco-
" nomic results cannot yet be clearly discerned in favor of a given type of motor or
" of a given system of working.

" 2° It is desirable that railway managements should continue their experiments
" in this direction and more especially investigate the classes of service to which
" this new motor is suitable, and the advantages it offers to the public and to the
" railway managements, particularly in the matter of cost.

" 3° Finally, it is important that any changes recognized or which may be here-
" after recognized, as likely to facilitate the advantageous use of automobile and
" automotor cars, should be introduced into the regulations in force. "

— These conclusions were adopted by the general meeting.

MISCELLANEOUS INFORMATION

[625 .145.2]

1. — Steel rails : their composition and cross-section (1),

By Robert JOB,

LATE CHEMIST, READING RAILROAD COMPANY.

(*Engineering News.*)

Twenty or thirty years ago, steel rails did not cause the difficulty which is found with the present product. This condition, which is only too familiar to every railroad man, is due to a number of causes.

In the first place, a vastly greater tonnage is handled to-day by the mills, and the same care is not used in the preparation and cropping of the ingots, while in the rolling much higher finishing temperatures are maintained, resulting in coarser structure with relatively rapid wear. In many cases, the composition is better to-day than formerly, yet in spite of what under present practice would be considered dangerous composition, it is a well-known fact that the old rails gave generally excellent service, this being due largely to thorough working of the steel down to a low finishing temperature.

Why is not the former close-grained, slow-wearing structure produced to-day? Is the change due merely to the insistent efforts of the mills for higher tonnage, or do other elements enter into the case? The answer is complex. In the first place, the increased weight of the present sections of 90 or 100 lb. per yard instead of 60 or 65 lb. has radically upset the ratio between the various components of the area of the rail, that is, head, web, and flange. The former is far thicker and of much greater mass than formerly, while the other parts, in many cases, have increased but little in thickness or even have decreased. As a result of these changes, the flange gets to the lowest temperature at which it can be rolled long before the head reaches the same temperature, so that even though the flange be fine grained and tough, as fine even as was obtained in the old practice, the crystals of steel in the head may be very coarse, since they were growing in size from the time that pressure upon them in the rolls ceased until the steel at that point had fallen below a dull red heat. This condition would mean relative rapid wear and brittleness.

From the above, it is evident that in order to get fine grained structure clear to center of head, two courses are open. Firstly, to rearrange the proportions of the rail in such manner that each component part shall reach the critical temperature at more nearly the same time, as in the old sections, or secondly, to change the heat treatment given the steel, either during the rolling or subsequently. By the first method, the large crystals would be prevented from forming, while by the second, even though formed, they would be broken up by the reheating.

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(1) Condensed from a paper read November 16 before the New York Railroad Club.

In some of the mills, it is common practice to hold the rail before the last pass with the object of giving greater toughness and better wearing qualities to the steel, owing to the finishing at a lower temperature. Unluckily the plan is of little benefit, since thereby a fairly fine granular structure is produced to a depth of only about an eighth of an inch from the surface. This, in service, is quickly worn away, exposing the coarse structure beneath.

As an example of the influence of heat treatment after rolling, it may be of interest to detail the results of an investigation carried out several years ago under our direction upon the Reading Railway. Eleven 90-lb. rails of coarse granular structure were, through the kindness of the Pennsylvania Steel Company, sawn in halves and one-half of each run into a reheating furnace, brought to a cherry red, and at once removed and let cool in the air. In the annealed rails, the coarse granular condition was entirely obliterated and replaced by a very fine structure of great toughness. These twenty-two rails were laid in track at Reading at a point where they were subject to slow, heavy traffic. All of them were in the same line, laid alternately, first an annealed rail, and then its untreated half. From time to time measurements were made of the contour with a rail indicator. After being subject to a traffic of approximately 88,128,000 tons we were surprised to find that the annealed rails showed 31·9 per cent the more rapid wear, while they also showed the greatest tendency to mash down and splinter. The average loss of weight was 2·85 lb. per yard for the untreated rails and 3·77 per yard for those treated. Upon cutting out strips from the heads and subjecting to tensile test we found the following averages :

	Natural.	Annealed.
Tensile strength, lb. per square inch	129,700	126,100
Elastic limit, lb. per square inch	80,600	70,225
Elongation, 2-inch section	21 per cent.	22 per cent.

The composition averaged about as follows :

Carbon.	0·540 per cent.
Phosphorus	0·079 —
Manganese	1·060 —
Sulphur	0·080 —
Silicon.	0·090 —

The clear teaching of the trial was that under heavy traffic high elastic limit is essential to the best service, and it was also evident that if one proposes to get greater toughness and safety by some treatment, like the annealing, which lowers the elastic limit, one should also, to get the best results, increase the carbon or manganese contents to the point at which the elastic limit will be high enough to resist crushing, even though the steel be somewhat unsound. In other words, the toughness and elasticity produced by the fine granular structure permit one to increase the hardening contents considerably beyond the point which otherwise would be safe, thus obtaining greater capacity for wear.

A good deal of discussion has arisen from time to time concerning the effects consequent upon overloading of rails, and in some instances, we have heard manufacturers attribute the crushing down and splintering of their product to the heavy wheel loads now prevalent.

The appearance of the fracture of a rail which has failed owing to overloading is distinctive.

The fracture generally takes place immediately over a tie, due, of course, to the repeated straining of the metal beyond its elastic limit. At first, merely a hair crack is found. This, with repeated bending, gradually extends into the rail and the broken surfaces become smooth, and darkened by oxidation. Finally, the remaining metal is too slight to support the weight of a passing load, and the final fracture occurs. We have taken one of these light rails from track, broken it under the drop, and found one of these typical cracks developing over each tie, showing clearly the need of close watchfulness in the maintenance of track subjected to heavy traffic.

We have referred above to the necessity of avoiding porosity and unsoundness of steel if good service is to be obtained. Curiously enough a frequent characteristic of nickel steel is somewhat allied to this condition. It is a matter of general observation that nickel steel rails have not given the service which was anticipated and hoped for, but that there has been a tendency to sliver and to have a life not all proportioned to the cost. Several years ago while investigating some of these rails we came upon a condition which seemed to account fully for this unfortunate behavior. An 80-lb. nickel-steel rail having 3·48 per cent of nickel was lightly etched and a number of dark spots appeared. These we found were not particles of slag or oxide due to failure to crop the ingots to clear metal, for the steel was thoroughly sound. The spots had a silvery appearance and where exceedingly hard, and evidently were either pure nickel or else an alloy high in nickel. The important point was that the metal was not homogeneous, and at these places appeared to be imperfectly welded, so that under severe stress the effect would be the same in a way as though the line of hard alloy had been a line of slag. There would be an imperfect bond and the surfaces would slip apart and slivering would result.

The important question remains : How can better rails than are now secured be obtained? We have already suggested that by modifying the section of the rail a finer granular form with its inherent toughness and tenacity may be obtained. By insisting upon cropping of ingots clear to sound metal, and by testing a rail-butt which is with certainty known to have been taken from the top of an ingot, so that if marked unsoundness be present, the heat may be rejected by the drop test, a reasonable degree of soundness can be secured, and slivering and crushing largely prevented. By increasing the hardness of the rail as much as is compatible with the character of the roadbed, the rate of wear may be decreased, but we believe that further aids are necessary and can before long be obtained. The Bessemer rail has filled an important need, particularly in the days of light, easily rolled sections and light wheel loads. Under present conditions, however, there is urgent demand for harder, tougher steel. In the Bessemer rail the hardness, with the proportion of phosphorus usually present, cannot be increased much beyond present practice, say 0·60 or 0·65 per cent carbon, without causing undue brittleness, and hence advantage has been taken of the basic open-hearth process by which phosphorus and sulphur can be nearly eliminated. With these elements of brittleness largely removed the proportion of carbon has been increased safely and with very favorable results to nearly 0·90 per cent, thus securing great hardness, together with great tenacity and a very low rate of wear. Bessemer rails will undoubtedly continue to be used for the lighter sections and in locations where traffic is light, but we believe that under the more exacting conditions this quality will before long disappear, replaced by the harder, tougher steel of the basic open-hearth process.

[625 .143.5]

2. — Trials of the Lakhovsky screwspike.

Figs. 1 to 21, pp. 365 to 372.

The French State Railway, consequent on a report of the *Comité de l'exploitation technique des chemins de fer*, has undertaken to make trials of this new method of securing rails to soft wood sleepers, and on a line with very heavy traffic.

The trials, which were initially on a small scale, led to the modification and simplification of the original pattern. They have proved sufficiently satisfactory to lead to their continuation and even extension, and 5,000 such screwspikes are going to be ordered. But owing to the present high price of metal, these new trials have been deferred.

Particulars of the Lakhovsky screwspike are given below.

I. — Description.

The Lakhovsky screwspike (figs. 1 and 2) consists of three parts : the *bolt*, the *nut* and the *split-bush*.

The *bolt* B, like the one now used, has a square flanged head ; the shank has a thread cut over part of its length.

This bolt screws into a *wing nut* E (fig. 2) which is coned. The wings *a* enter between the two halves of the bush ; the latter thus prevents the rotation of the nut which is compelled to travel up or down when the bolt is turned.

The shank of the bolt is inside two hollow half-cylinders of steel C which are called *shells*, and form a split-bush. They are forced well into the wood of the sleeper as soon as the bolt is turned, even if but little force is used. Buttress-shaped grooves on the outside of the shells add to the firmness, and prevent any slipping or drawing of the spike.

When the screwspike is ready to be put in, the nut is on the bolt and the wings just enter the split-bush. The body of the arrangement then has the form of a cylinder which only has to be inserted in the hole made for the purpose in the sleeper.

II. — Application.

A. — On lines with Vignoles rails.

The Lakhovsky screwspikes are delivered with their shells CC tied on by an iron wire FF (fig. 3), ready for use.

They are put in with pincers (fig. 4) having unequal jaws MM ; the bolt is held between the head and the shells, so that the latter are prevented from slipping up when the screwspike is inserted into the hole in the sleeper.

A vertical hole is bored into the sleeper, by means of an auger ; the distance between the centre of this hole and the edge of the seating is equal to half the diameter of the shank of the screw (fig. 5).

In the case of sleepers which have already been used, the hole is enlarged by means of a plug-end auger (fig. 6).

The screwspike is then seized between the head and the shells by the jaws M of the pincers

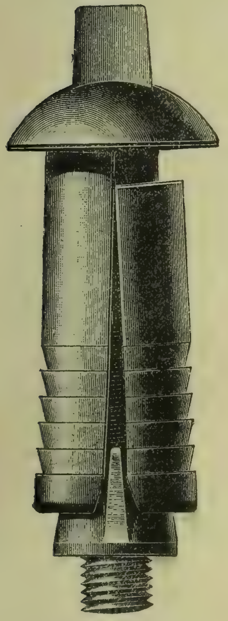

Fig. 1.
General view.

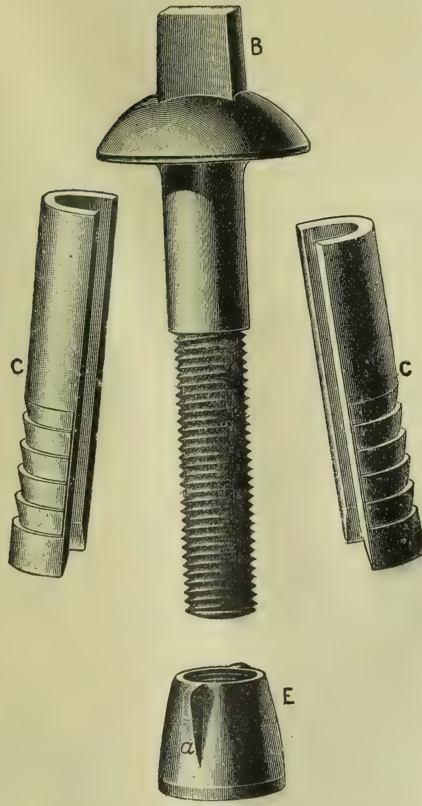

Fig. 2. — Details of screwspike.

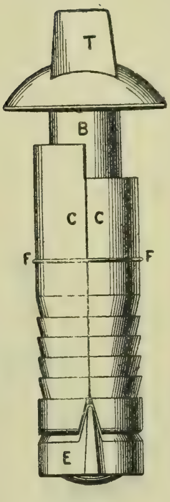

Fig. 3.

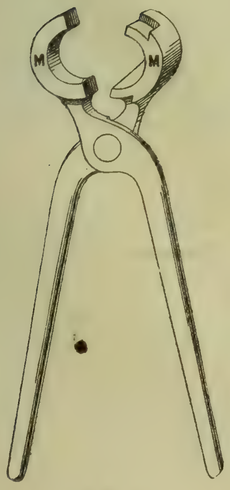

Fig. 4.

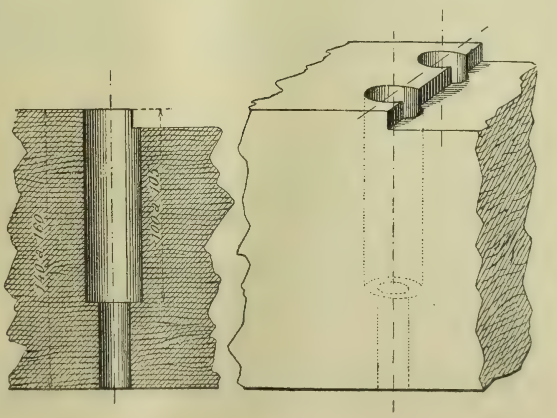

Fig. 5.

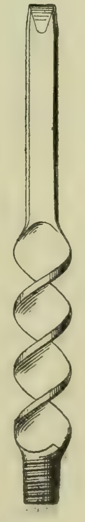

Fig. 6.

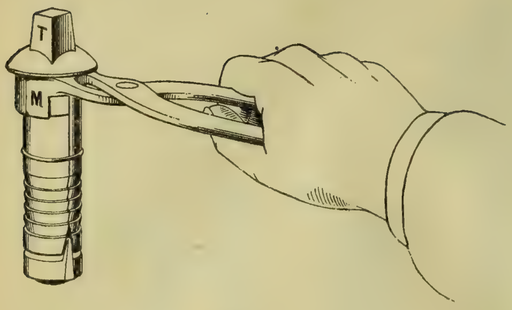

Fig. 7.

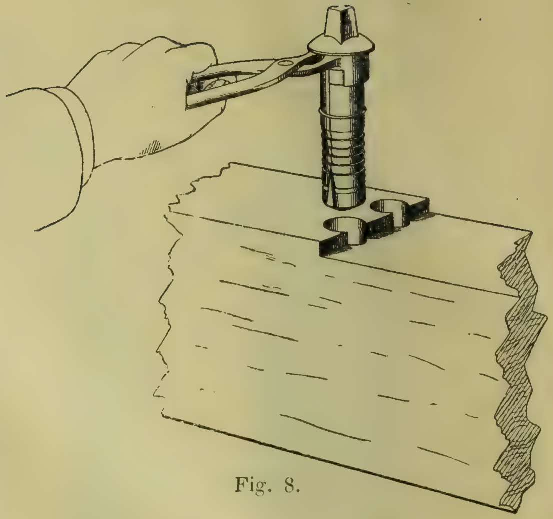

Fig. 8.

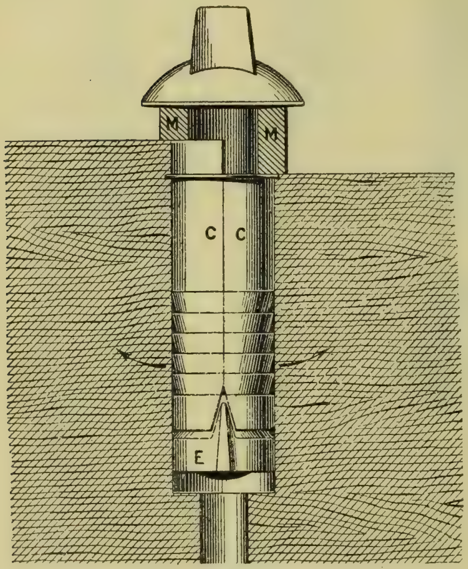

Fig. 9.

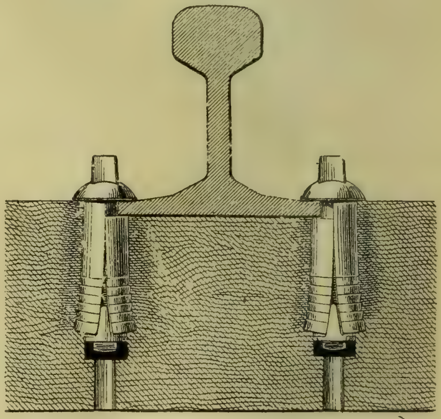

Fig. 10.

(fig. 7) and the nut is then drawn up by turning the head T of the bolt by hand until the head and shells are well against the sides of the jaws.

The bottom end of the bolt, the nut and the shells are then dipped into a mixture of tar and heavy oil (tar 70 per cent, oil 30 per cent).

The screwspike is then held vertically over the hole in the sleeper, *taking care that the shells open in the direction of the axis of the sleeper* (fig. 8).

The screwspike is then driven in by *gentle blows of a wooden mallet,* until the top of the shells is flush with the edges of the hole (fig. 9).

The grooves on the outer side of the shells offer a slight resistance to the insertion, which is thus managed gently, not with violence.

The device is then in place. The other screwspikes in the sleeper are then inserted in the same way.

The bolts are then screwed out, the rail is set in place, the bolts are put in and successively screwed tight (fig. 10).

B. — **On lines with chairs.**

The Lakhovsky screwspikes are delivered with their shells CC tied on by an iron wire FF (fig. 11), ready for use.

They are put in with pincers (fig. 12); the bolt is held between the head and the shells, so that the latter are prevented from slipping up when the screwspike is inserted into the hole in the sleeper.

A vertical hole is bored into the sleeper, by means of an auger having a diameter equal to the diameter of the bolt with its shells; the hole is 100 to 105 millimetres (3 $^{15}/_{16}$ to 4 $^{1}/_{8}$ inches) deep (fig. 13).

In the case of sleepers which have already been used, the hole is enlarged by means of a plug-end auger (fig. 14).

The screwspike is then seized between the head and the shells by the jaws M of the pincers (fig. 15) and the nut is then drawn up by turning the head T of the bolt by hand until the head and shells are well against the sides of the jaws.

The bottom end of the bolt, the nut and the shells are then dipped into a mixture of tar and heavy oil (tar 70 per cent, oil 30 per cent).

The screwspike is then held vertically over the hole in the sleeper, *taking care that the shells open in the direction of the axis of the sleeper* (fig. 16).

The screwspike is then driven in by *gentle blows of a wooden mallet,* until the top of the shells is flush with the edges of the hole (fig. 17).

The grooves on the outer side of the shells offer a slight resistance to the insertion, which is thus managed gently, not violently.

The device is then in place. The other screwspikes for the chair are then inserted in the same way.

The bolts are then screwed out, the chair is put in place, the bolts are put in and successively screwed tight (fig. 18).

Note. — The tightening is done gradually: it is not necessary to use much force. A wrench with 20 or 25 centimetre (8 or 10 inches) arms will suffice.

ORGANIZATION OF THE WORK. — SUNDRY REMARKS.

In organizing the plate-laying work on an existing line, if a good result is to be obtained, it is necessary to work systematically and to give each man always the same work.

Without giving any definite plan, which will vary with the number of men available, it is however possible to give some general indications.

The work may be considered to consist of four sets of operations :

1° Removing the old fastenings and cleaning the sleepers;
2° Boring the holes;
3° Putting in the screwspikes;
4° Taking out the bolts and screwing them in again after the chair has been put in place.

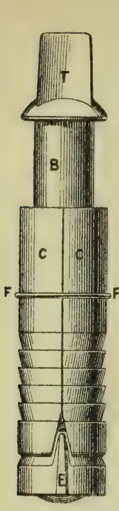

Fig. 11.

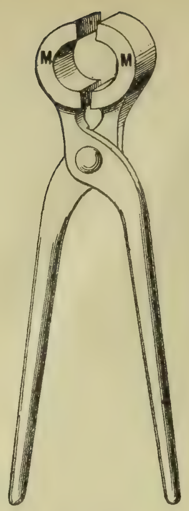

Fig. 12.

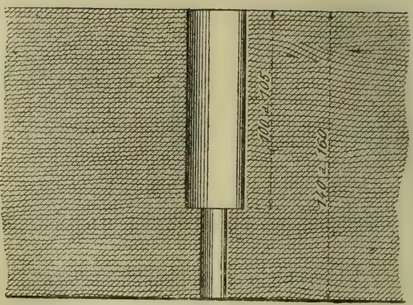

Fig. 13.

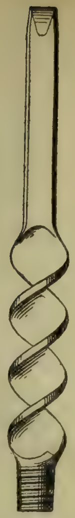

Fig. 14.

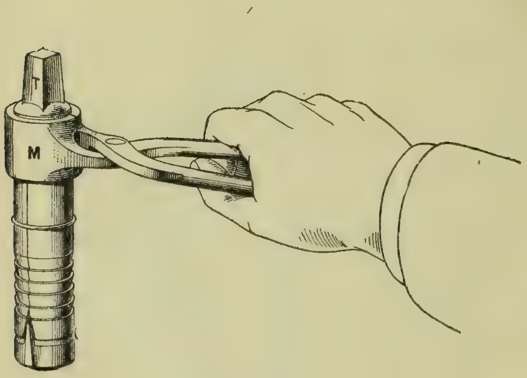

Fig. 15.

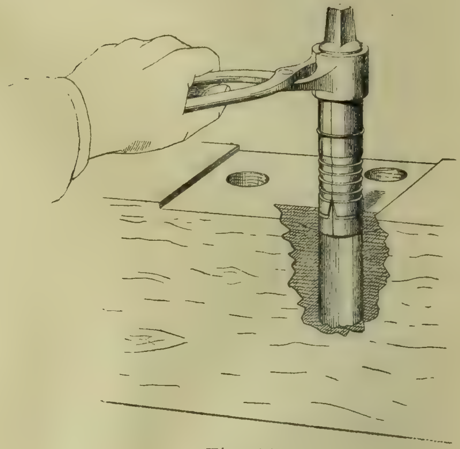

Fig. 16.

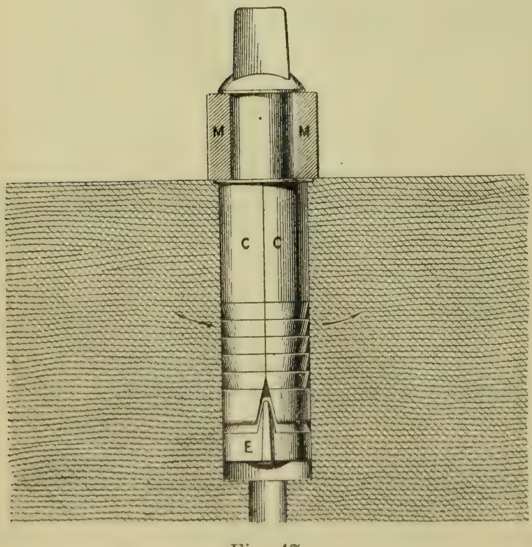

Fig. 17.

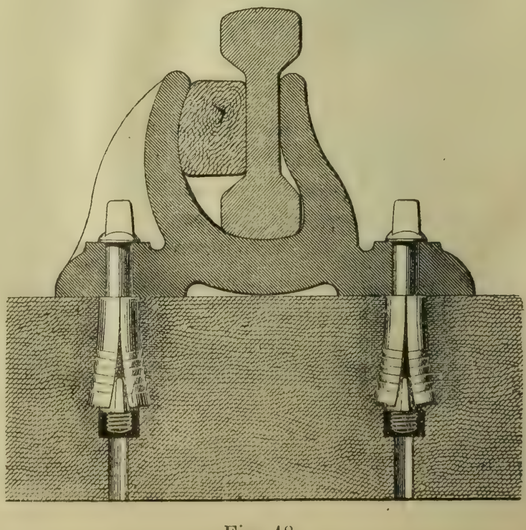

Fig. 18.

If possible, the gang will be divided into two sections, the one attending to the ends of the sleepers carrying the right hand line of rails, the others to the left hand rails.

Each section will be divided into four sets of men, each set attending to one of the operations mentioned above.

Boring the holes takes longest. One man attends to it; and the time he requires for boring the holes at the one end of the sleeper will serve as basis for determining the number of men required for the other operations, so that the four sets of operations may take the same time, four successive sleepers being worked at simultaneously.

It is clear that as the operations are all done consecutively on each sleeper, progress will be very quick.

We of course assume that the whole gang starts on and finishes a given section of line in each working period, stripping the track, putting in the fastenings and securing the track again.

With such an organization doing regular work, the time required per screwspike and per man varies between two minutes and two minutes and a half.

This result may be achieved with men not familiar with the screwspike, during a number of hours of work; ten hours as a maximum.

Boring. — Two varieties of auger are used for this operation : a shell-auger and a twisted auger.

In the first place the depth of hole to be bored is determined.

This depth must be equal to the length of the shells and of the nut at their lower end, when in position.

On each auger a line is marked with a three-square file, in order to show the operator when the hole is deep enough.

The twisted auger has a plug-end which is introduced into the hole of a former screwspike and acts a guide enabling the hole to be enlarged, keeping the direction true.

The shell auger has no guide; the holes are cut more quickly and are cleaner, and the shavings are taken out more easily and completely.

It is advisable to use both tools : the twisted auger is used first to start the new hole, and it is then finished with the shell auger.

Shells. — The shells must be placed *so that the splits are perpendicular to the axis of the sleeper*, whether the sleeper be a transverse or a longitudinal one. As the axis is along the fibres of the wood, when the shells open they compress the grain endways, and not sideways, which would tend to separate it and split the sleeper. Nuts and threads of the screwspike. In order to prevent rusting, the whole nut and the bottom of the shells are dipped in grease or very liquid tar, or better still in heavy oil, or in a suitable mixture of oil and grease, oil and tar.

The same is done with the threaded part of the bolt before it is screwed in.

Head. — To strike on the head which is of very hard steel, use an iron striker weighing 6 to 7 kilograms (13 to 15 lb.); this is better than a steel key-hammer which is destructive and not heavy enough.

Screwing in and tightening up. — When the bolt is to be put back, it must be pushed down to the nut, without any sudden blows which might disturb the position of the latter; for this must be in the position in which it has been left.

In screwing in, care must be taken to start the thread properly. Then when it is certain that all the screwspikes of one and the same chair have entered their nuts properly, they are tightened up as required.

One man alone must attend to this tightening, *and he must not use much force.* All that is required is that the bolt should draw up the nut sufficiently to separate the shells so that they take against the sides of the hole and are driven a little into the wood.

III. — **Action and advantages of this screwspike according to the inventor.**

ACTION.

The description given above clearly shows how this screwspike acts.

The threaded shank of the screwspike proper having entered the nut, if we then turn the screwspike to the right, by means of a wrench or key, this rotation makes the nut ascend.

The nut cannot in fact turn with the spike because this is prevented by the wings which are between the shells. As it cannot turn, it will travel up; as it travels up the wedge shape of the wing and the coned shape of the nut will open out the shells at the bottom, as if they were hinged at the top inner edges which will still be together.

The fastening will then have the shape of a frustum of a cone with its major diameter inside the sleeper (fig. 19).

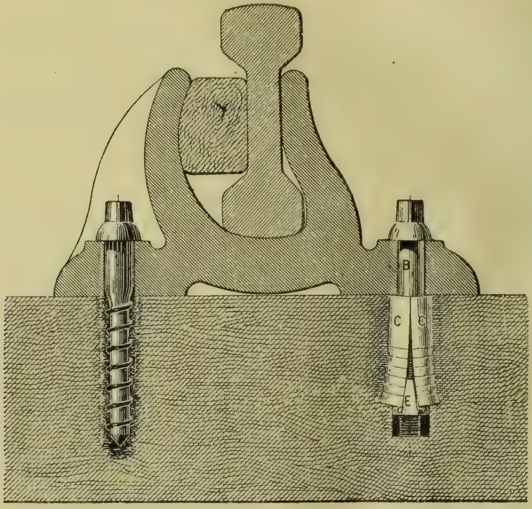

Fig. 19. — Ordinary screwspike compared with Lakhovsky screwspike.

It will be easily understood that it is *impossible to draw out this frustum.*

Moreover, it proved impossible, in all the trials made, to draw the fastening.

The threaded shank became fractured when sufficient tension was applied; a stress of about 7,000 kilograms (15,430 lb.) was required for this purpose.

The fastening will never have to stand such a stress, nor even half of it.

If there is any play in the fastening, when the wood becomes softened, a touch of the spanner will set everything right again.

The advantage gained in this way is never lost, for the nut is kept in position by its wings which are nipped strongly by the shells, and it is impossible for it to turn. It therefore cannot become loose, even if subjected to continuous vibration, however strong and quick.

TECHNICAL ADVANTAGES.

When the screwspike invented by Mr. George Lakhovsky is used, the fastening of the sleeper has acquired the strength necessary for the much heavier rolling stock now used and it will be able to stand without difficulty the continual growth which goes on upon railways.

This screwspike is certainly fully equal to the important work it has to perform.

Thanks to it, there is now a *close and exact homogeneity,* hitherto unknown, between the two parts of the track which we considered at the beginning of this paper : the wood part and the metal part; and that in spite of the wear and the relative weaknesses which may appear.

The track forms from now one united whole.

It is certain, and it will be easily understood, that the new screwspike stands, without becoming strained, the drawing forces it is subjected to, which result from all the forces acting on the track : lateral stresses, stresses tending to cant the rails, rolling forces, elastic reactions.

It will keep the rails true to gauge, an essential point as regards safety.

It can, moreover, be subjected to shock, to stresses in all directions without giving way; this is due to its energetic tightening action which is kept up indefinitely by its shells, which form a metallic lining which effectually protects the wood.

Play is totally prevented; hence there is no more question of rattling or of water entering the sleeper.

As there is no play between the sleeper and the chair, the one will always follow the other in all the movements transmitted by the rail when a train passes.

The cutting of the chairs into the sleeper will disappear together with the rattling which conduced to it.

Moreover, the chair now rests on solid metallic supports formed by the upper edges of the shells flush with the surface of the sleeper and protecting the latter against the action of the chair.

The manifest superiority of the Lakhovsky screwspike is already apparent.

But in order to consider the worst possibilities, as against these many advantages, let us assume that in spite of the most perfect adhesion, water will work in and act on the wood, soften it and will even in the course of a certain number of years, begin to make it rot.

It may also be assumed that the chair will cut into the sleeper in spite of the metallic support.

Even though these assumptions were to prove true, the superiority of the screwspike remains manifest.

For if during the continual examinations made of the permanent way, such condition of the wood is observed, a good pull at a spanner will tighten up the screwspikes and the softened wood is once more compressed under the chair. The empty space is closed up.

This compression which extends to the surrounding molecules thus produces a more solid mass in which the screwspike holds firmly.

At the same time, the chair is pressed firmly down on its adzed seating; the latter is not very necessary, and there is no need of re-adzing; consequently the chair is not displaced.

Take the worst conditions, and let us assume the chair has cut deep into the sleeper, that it is even canting. All this can be easily remedied by interposing slabs (felt, wood or paper).

This operation would be very simple and inexpensive, if sets of slabs were kept ready cut to size, that of the seat of the chair.

Let us finally assume, in order to exhaust all possibilities and meet all objections, that it is necessary to clean up and re-adze the seating. What can interfere? the shells which are flush with the surface? Nothing is easier than to drive them in 2, 5 or 10 millimetres ($^{5}/_{64}$, $^{13}/_{64}$ or $^{25}/_{64}$ inch) further. The operations desired can then be carried out.

This property of strongly compressing the molecules of the wood, which we have mentioned above, makes it now possible *to use soft wood,* formerly much objected to owing to the readiness with which play results between the existing screwspike and such wood.

It will no longer be necessary to use only oak.

Pine sleepers can be used without hesitation.

It is just in the soft woods that the Lakhovsky screwspike best shows the qualities inherent to it.

The advantage accruing from the fact that it is unnecessary to cut seatings (which is partly owing to the resistance of the shells) makes itself still more felt in the case of Vignoles tracks (figs. 20 and 21).

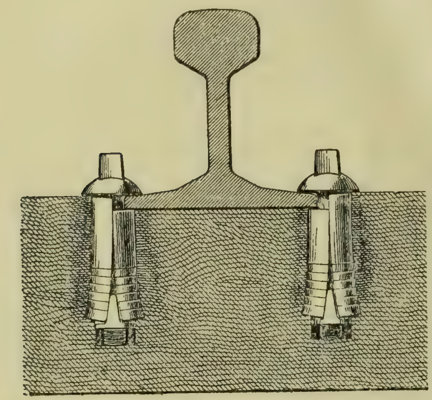

Fig. 20. — Lakhovsky screwspikes used with Vignoles rail.

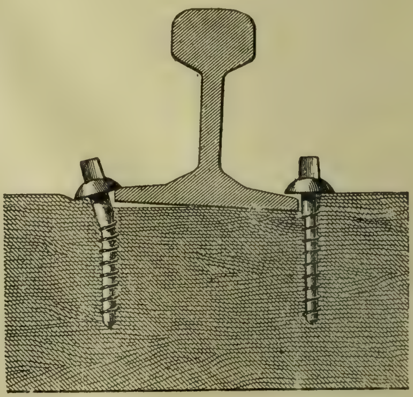

Fig. 21. — Effect of Vignoles rail canting and cutting into sleeper.

In these the immediate result of the canting of the rail is to drive in the edge of the flange on which it tends to turn, and to drive in, in the other direction, the head of the screwspike holding the opposite flange (fig. 21).

It is easy to understand that as the two edges of the flange rest on the inner shells and the heads of the screwspike on the outer shells they can no longer be driven into the wood and consequently *the rail cannot cant.*

ECONOMIC ADVANTAGES.

We have stated that the time required for putting in these screwspikes varies between two and two and a half minutes per man and per screwspike. This was the time taken by gangs working under supervision. It may be understood, and practically admitted, that a gang not under supervision will take one or two minutes more, time lost; the time will probably vary between three and four minutes per man and per screwspike. This is half the time required for the usual re-adzing of sleepers when the ordinary screwspikes are used. Thus if, when old screwspikes have to be taken out or when the sleepers should be re-adzed in the ordinary practice Lakhovsky screwspikes are put in instead, the labour will cost half of what re-adzing would cost.

Only the price of the screwspike is higher.

It costs at present 27 centimes (2·59 pence) (this price will be lower in future); thus it costs 6 to 10 centimes (0·6 to 1 penny) more than the screwspike now used.

But this extra expense which is already counteracted by the saving in labour, is much more than counterbalanced later on; firstly because the sleeper will have a longer life as no re-adzing will be required, and secondly by the saving in maintenance.

Once the screwspike is in place it is rigid; it cannot be drawn and cannot work loose.

Should any play result, we know that a touch of the spanner will remove it; *this is all the maintenance necessary.*

The saving realized in this way will amount to at least three fourths of the work now required for the maintenance of a track.

We have moreover a basis the comparison : the existing roads with metal sleepers. On such roads, maintenance costs one fourth to one fifth of what it does on roads with wooden sleepers, as re-adzing is eliminated.

Thus roads with wooden sleepers and Lakhovsky screwspikes have at all events the same advantages as roads with metal sleepers, without having the disadvantages.

In maintenance work, several days per year will be all that is required to examine the tightness of the spikes and keep it constant; to keep the track perfect, the only other thing required is to adjust it.

Anyone who considers track maintenance, will at once see the great economy to be realized in maintenance, and the great safety resulting from more frequent and easy inspection, costing less and taking less time.

In the case of new tracks, the same economy in maintenance will of course come in. But other economies will also be realized in construction cost, as only four screwspikes will be used instead of six, in the case of tracks with chairs, and as pine sleepers will be used instead of oak.

Thus at present the sleeper for a chair track costs :

Oak sleeper, seating cut, pickled		5·40 francs (4*s*. 3·8*d*.).
Screwspikes	6 at 0·18 (1·73*d*.) =	1·08 — (0*s*. 10.4*d*.).
	Total	6·48 francs (5*s*. 2·2*d*.).

With the newspikes, the cost per sleeper will be :

Pine sleeper, seating cut pickled		3·50 francs (2*s*. 9·6*d*.).
Screwspikes	4 at 0·27 (2·59*d*.) =	1·08 — (0*s*. 10·4*d*.).
	Total	4·58 francs (3*s*. 8·0*d*.).

Thus the saving per sleeper will amount to 1·90 francs (1*s*. 6·2*d*.).

[625 .216]

3. — The Darling automatic coupler. (Davidson pattern.)

Fig. 22, p. 374.

We herewith give illustrations (fig. 22) of a pattern of automatic coupler, trials of which have been made in England.

The original feature of this coupler is the reversal of the hook, which has its point

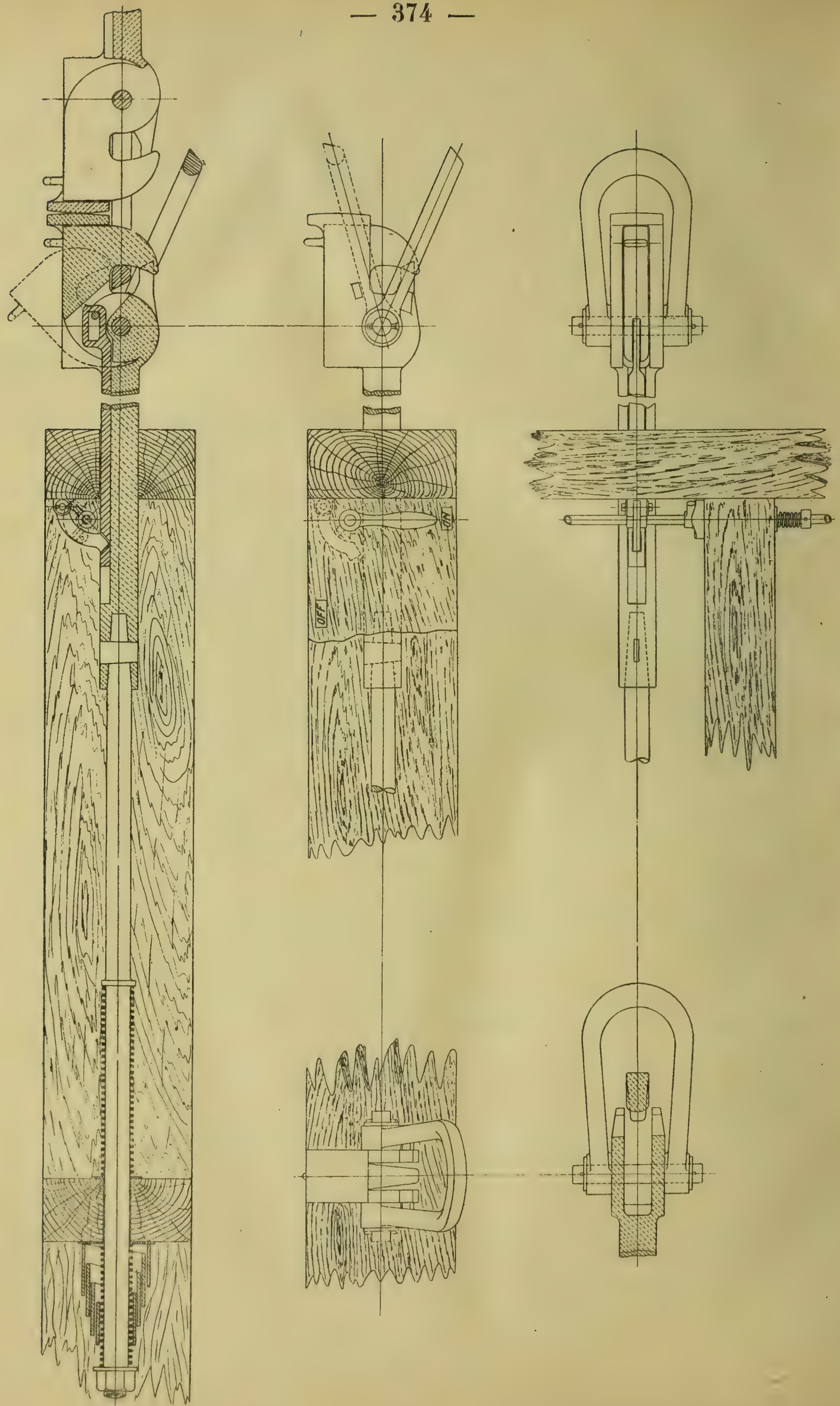

Fig. 22 — Darling automatic coupler.

below, instead of either above, as in most of the ordinary couplers, or at the side, as in the American coupler.

This position makes it possible to use the link itself as an inclined plane for guiding the link of another vehicle into place so that the hook can enter it; the links are tapered so as to prevent two from clashing if at the same height.

The hook which is pivoted on the bar has at the top a small eye to which a chain can be attached by which the coupling can be undone from outside the track. It is also possible to apply a coupling pole to this eye and lift the hook, even when the coupling is in a state of tension.

The inventor has also provided a device for uncoupling : all that is required is the operation of a small handle on the outside of the frame.

A finger fixed to the shaft operated by this handle makes it possible, if desired, to lock in position a piece which slides in the upper part of the drawbar, and which acts on the hook by means of a pin and link.

In one of the positions of the handle, the finger is raised and the sliding piece moves with the drawbar; then it does not act on the hook. But in the other position, the lowered finger locks the sliding piece, and if tension is applied to the coupler, it opens automatically.

The trials made seem to show that with this pattern of coupler coupling can be effected even when there is a difference in level of about 10 centimetres (4 inches) and on a curve having a radius of 40 metres (2 chains).

[625 .254]

4. — Erratic actions of the vacuum brake.

(Letter of an engineer.)

(*Railway Gazette.*)

The influence of centrifugal forces seems to have been overlooked, or improperly considered in the design and construction of the automatic vacuum brake as now most generally, though not universally used. The proper action of this design of brake, depends absolutely upon an effective seating of a small brass ball check valve used with each brake cylinder. In order that the brakes may work properly when set, this valve must rest against its seat and tightly close a small passage leading to a vacuum reservoir used with each brake cylinder. If the ball valve remain unseated, there is no brake force from that cylinder.

There are slight variations in the details of construction in valves of this type made at different periods, but they all allow the ball valve to have more or less free movement from its seat in the valve cage, crosswise of the vehicle, and therefore radial to any curve in the line through which the vehicle may be running. When running on a tangent with the brakes released, the ball valves are either away from their seats, or they are against them with very slight pressure, and this is a necessary feature of the vacuum brake, when ball check valves are used.

In passing around a curve in the line, centrifugal force, acting upon these ball valves, tends to remove or hold away from their seats all of them which can move radially outward, and this tendency is greater at higher speeds and on sharper curves. At the same time centrifugal force, acting upon the car body, causes it to roll outward at the top, as is frequently noticed. The valve seats against which the ball check valves rest, partake of this motion of the car body, which thus assists in unseating or in holding away from their seats all the ball valves which can move radially outwards.

When there is not sufficient curve of adjustment between the tangent and the curve in which to properly obtain the superelevation of the outer rail, or when this superelevation is too little for the degree of curvature and the speed at which the train is running, the sudden rolling of the car body by centrifugal force, combined with the centrifugal force acting on the ball valves themselves, is sufficiently quick and powerful to throw many of the ball check valves now in use off their seats. In some such cases the centrifugal force, acting upon the ball valves after they have been unseated by a single rolling motion of the car body as above described, is alone sufficient to hold them from their seats until the curve in the line is passed, even though the driver attempts to set the brakes slowly, because there is not sufficient force in the entering air current to seat them.

From tests which have been made, it is shown that at speeds frequently attained on curves, some of these valves may be held away from their seats by centrifugal force and remain unseated when air is gradually admitted to set the brakes, because the current of air is not strong enough to close the valves against the action of centrifugal forces to hold them open. If air be admitted more quickly, at the locomotive only, to set the brakes, the current is too gradual further rearward to ensure the closure of these valves against the action of centrifugal forces to hold them open.

This wrong admission of air into the vacuum reservoirs by the ball-check valves, together with leakage past the piston packing rings, may destroy the power of the brakes entirely, because when the vacuum in the reservoirs has fallen to 8 or 10 inches by such action before the brake piston is lifted, any further attempt to set the brakes is ineffective, even if the ball valves should then have resumed their proper positions. The fact that no proper braking is had in any such case can only be known to the driver by his observing that the speed has not been properly reduced. It is then usally too late for remedy : the driver may recreate the vacuum and try again if he has time and space to do so, after he has found that the first attempt at setting the brakes was ineffective. In such cases, when the vacuum in the reservoir is once destroyed, it requires a longer time to recreate an effective vacuum than is required after an ordinary proper setting of the brakes, when the vacuum in the reservoir has not been destroyed.

There is a still possible wrong working of the ball check-valve device as a whole, which has to do with the hand-release attachment. When the brakes are fully set and the train is passing, even at moderate speed, though, perhaps, faster than usual at such point, over a crossover or sharp curve, as sometimes happens upon nearing a station or elsewhere, the centrifugal force, or inertia, of the valve-cage and this hand-release device, including the lever and its attachments, may sometimes release the brakes, when it is important that they should remain set, because there is nothing but the resistance to flexure of the rubber diaphragm and friction, to be overcome at first, and a slight air pressure against the ball check valve later to prevent such action by centrifugal force.

Many cases of loss of train control by the drivers, which have never been satisfactorily explained, have probably been due to the influence of these centrifugal forces, and, if possible, the construction should be altered, so as to remove the danger. Otherwise the same causes will continue to produce similar results under similar conditions.

[621 .134.3]

5. — Single expansion and lower pressures.

(*Railroad Gazette.*)

The single-expansion locomotive, after all the efforts which have been made to supplant it, still stands as an acceptable device for handling railroad trains. Many years have passed since compound cylinders were first used in locomotive service, and a considerable period has elapsed since the advent of superheating locomotives, but neither compounding nor superheating have yet gained for themselves a place of real security in the railroad practice of this country, while single-expansion locomotives are being built at a rate never before known. Notwithstanding these facts, train speeds have steadily increased, the loading behind tenders has been made greater, and the cost of operation has been reduced. One reason for this is to be found in the fact that many of those devices which have been put forward as capable of improving locomotive performance, are effective only while the cylinders are using steam. They cannot effect a saving in the amount of coal used in firing up, nor in maintaining the temperature of the machine while it is being held at stations or on sidings. Another reason is to be found in the exceptionally high qualities of the single-expansion locomotive, which in spite of the competition which has been forced against it, and while remaining simple and unadorned, continues to do the business of the country. Its high efficiency has many times been referred to in these columns. The fact that it develops at its drawbar a horse-power in return for the consumption of from 3 to 4 pounds of coal per hour, has recently been referred to. Its acceptability for hard and continuous work in return for a minimum of attention is well understood. But however complimentary to the single-expansion locomotive these reflections may appear, it will be well to remember always that it is not yet entirely perfect. The process of developing the single-expansion locomotive is in fact still an active one. Each year adds something to the sum of available information concerning its actions, by the application of which the proportions of some important part are fixed with greater certainty. It is by this slow process of evolution that the efficiency of the machine as a whole has been, and in the future will continue to be, raised. A matter of more than ordinary moment which has recently been brought to the attention of locomotive designers, the acceptance of which is likely to do much for the betterment of the locomotive, is a determination of the pressure which is most economical for such service. Pressures have for many years been steadily increasing till the limit of 200 lb. has been reached and passed. It is not shown by authority, which will generally be accepted as satisfactory, that under ordinary conditions of service, a pressure of from 160 to 180 lb. will be found more economical than any other.

As locomotives have grown in size, there has been a steady increase in boiler pressures, with the result that those who seek to further augment the power of locomotives have come almost intuitively to look forward to higher pressures as a means through which to accomplish the desired results. The feeling has been prevalent among locomotive users that high steam pressure is a necessary accompaniment to the development of high power. That such a conception is not justified by the facts is well shown by a paper recently read before the Western Railway Club (1), presenting the results of a large number of tests disclosing the performance of the engine and boiler under a wide range of pressures. A conclusion of the paper is to the effect that single-expansion engines should ordinarily carry pressures no higher than 180 lb., and that such locomotives will perform well the service expected of them if designed for pressures as low as 160 lb. While the significance of this statement may not at first be fully appreciated, it is understood to have been based on carefully conducted work, and sooner or later its force will doubtless be generally accepted. A full array of the data underlying the statement is promised to the reading public through the medium of a forthcoming report of the Carnegie Institution of Washington.

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(1) " High steam pressure in locomotive service ", a paper by W. F. M. Goss, presented at the November meeting of the Western Railway Club. This paper was published in full in the *Railroad Gazette* of November 30, 1906, pp. 489 to 492. An abstract of this paper will be also published in the number of April 1907 of the *Bulletin of the Railway Congress*.

The assertion that a running pressure of from 160 to 180 lb. will be found most economical for service in a single-expansion locomotive, does not imply that existing locomotives designed for higher pressures should have their pressures reduced to the limit stated, for in all cases cylinders must be proportioned to boiler pressure, and ordinarily the pressure should not be reduced unless the cylinder diameters are increased. It may sometimes happen that a class of locomotives may be improved by imposing some reduction in pressure but such a course cannot be contemplated in a general proposition. Again, it should be borne in mind that a reduction of pressure to the limit stated will not operate to reduce the power, if the cylinders are proportioned for the pressure from which they are to be supplied with steam. The greatest power will be developed under those conditions which permit the highest economy in operation. Since it is proved that a single-expansion locomotive is ordinarily more efficient at a pressure of 180 lb. than when operated under higher pressure, it follows that at this pressure it may be worked to a higher power than can be obtained if served with any other pressure whatsoever. Finally, in this connection, due emphasis should be given the fact that the selection of 160 to 180 lb. as running pressure of the locomotive, is not to be regarded as a backward step. The problem in design is to increase the efficiency and power of the proposed locomotive, as compared with those previously built, and if it is shown that a reduction of pressure is a means to such an end, real progress is to be achieved by using the lower pressure.

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[016 .385. (02]

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(February, 1907.)

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1906 **625** .13 (09.3 (.494)

ALLARD (Commandant).

Histoire du tunnel et des travaux du Simplon.

Besançon, imprimerie Jacquin. In-8°, 28 pages et carte des tunnels des Alpes et des voies d'accès projetées. (Prix : 50 centimes.)

1906 **385**. (02

Annuaire Marchal des chemins de fer et des tramways.

Paris, Dunod & Pinat. 21e année. 1 volume in-8° (250 × 165), 1,300 pages. (Prix : 7 francs.)

1906 **385**. (02

Annuaire du ministère des travaux publics, des postes et des télégraphes. (Année 1906.)

Paris, Bernard, éditeur. 1 volume in-8° de 844 pages. (Prix : 10 francs.)

1906 **625** .13

BONJOUR (Félix), député, rédacteur en chef de *La Revue*.

Le percement du Simplon. I. Les négociations. — II. La ligne de Jougne et Frasne-Vallorbe.

Lausanne, Rédaction de *La Revue*. (Prix : 1 franc.)

1906 **621** .99

FRÉMONT (Ch.).

Étude expérimentale du rivetage.

Paris, Société d'encouragement pour l'industrie nationale. In-4° (285 × 230), 148 pages avec nombreuses figures.

1906 **385** .15 (.44)

GILLET (Pierre), docteur en droit.

Le rachat des compagnies de chemins de fer en France (thèse).

Besançon, imprimerie Jacquin. In-8°, 260 pages.

1907 **621** .32

GRAFFIGNY (H. DE).

La lumière électrique. Générateurs d'électricité ; dynamos et alternateurs-accumulateurs ; distribution de la lumière ; éclairage à air ; éclairage par incandescence.

Mayenne, imprimerie Colin ; Paris, librairie des publications populaires.

1906 **656** .23 (02

LAMY (L.), directeur du *Bulletin des transports*.

Manuel pratique des transports par chemins de fer. Voyageurs. Marchandises. Colis postaux. Avaries, pertes, retards et fourniture des wagons. (Abrégé de la 5e édition.)

Poitiers, imprimerie Blais & Roy ; Paris, l'auteur. In-8°, 128 pages. (Prix : 2 francs.)

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(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjoinly with the Office Bibliographique International, of Brussels. (See "Bibliographical Decimal Classification as applied to Railway Science," by L. Weissenbruch, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

N. B. — The Monthly Bibliography is printed on one side only so that it may be cut up into slips and pasted on labels for catalogues and indexes.

1906 **62**. (02

MILANDRE (Ch.), ingénieur des arts et métiers, & **BOUQUET** (R.), ingénieur des arts et manufactures.

Notes et formules de l'ingénieur et du constructeur-mécanicien. Mathématiques, mécanique, électricité, chemins de fer, mines et métallurgie, etc. Publiées sous la direction de Ch. Vigreux, ingénieur des arts et manufactures.

Paris, E. Bernard. 15ᵉ édition, in-16 de plus de 1,800 pages, avec plus de 1,400 figures dans le texte. (Prix : 12 fr. 50 c.)

1906 **385**. (08 (.493) & **313** .385 (.493)

MINISTÈRE DES CHEMINS DE FER, POSTES ET TÉLÉGRAPHES DE BELGIQUE.

Compte rendu des opérations des chemins de fer, postes et télégraphes, téléphones et marine, pendant l'année 1905. Rapport présenté aux Chambres législatives. Accompagné d'une carte officielle des chemins de fer de la Belgique.

Bruxelles, J. Goemaere. Grand in-4° (320 × 210), 185-24-36-12-xi pages. (Prix : 7 francs.)

In German.

1907 **385**. (02

Engelmann's Kalender für Eisenbahn-Beamte des deutschen Reiches. Mit besondere Berücksicht. der preussisch-hessischen Staatsbahnen.

Berlin, J. Engelmann. 25. Jahrgang, 2 Teile, in-8°, vii-383 und 354 Seiten mit 1 Tafel. (Preis : 3 Mark.)

1907 **62**. (02

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Berlin, Julius Springer. XXIX. Jahrgang, 2 Teilen mit zahlreichen Abbildungen und einer Eisenbahnkarte. (Preis : 3 Mark.)

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Handbuch der Ingenieurwissenschaften. 5. Teil, 8. Band : **Lokomotiv-Steilbahnen und Seilbahnen.** Bearbeitet von Roman Abt & Siegfried Abt. Herausgegeben von F. Loewe und Dr. H. Zimmermann

Leipzig, W. Engelmann. 2. Auflage, in-8°, x-300 Seiten, 410 Abbildungen im Text und 2 Tabellen. (Preis : 10 Mark.)

1906 **621**. 7

LEWIN (C. M.), Diplom-Ingenieur.

Werkstättenbuchführung für moderne Fabrikbetriebe.

Berlin, Verlag von Julius Springer. (Preis : 5 Mark.)

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STAHN (Gustav), Rechnungsrat.

Die Grundzüge des Etatswesens und die Finanzordnung der preussisch-hessischen Staatseisenbahnverwaltung.

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Statistik der Kleinbahnen im deutschen Reich für das Jahr 1905. (*Zeitschrift für Kleinbahnen*, 1907. Ergänzungsheft.)

Berlin, Verlag von Julius Springer. In-folio, 191 Seiten.

1907 **656** .2 (02

STRUCK (R.), Regierungs- und Baurat, Mitglied der königlichen Eisenbahndirektion, Halle-a.-S.

Grundzüge des Betriebsdienstes auf den preussisch-hessischen Staatsbahnen. Ein Leitfaden für Anwärter und Beamte des Betriebsdienstes.

Berlin, W. Druck und Verlag von R. Oldenbourg. In-8°, 194 Seiten mit 7 Abbildungen. (Preis : 3 Mark.)

In English

1906 **721** .9 (01

BUEL (Albert Wells).

Reinforced concrete. Part I : Methods of calculation. Part II : Representative structures. Part III : Methods of construction, by C. S. Hill.

New York, Engineering News Publishing Co. 8vo, 12 + 499 pages, ill., tables, diagrams. (Price : $5.)

1906 **62**. (03

FOLLOWS (G. Herbert).

Universal dictionary of mechanical drawing.

New York, Engineering News Publishing Co. 8vo, cloth, 60 pages, ill. diagrams. (Price : $1.)

1906 **625** .113

HENDERSON (Reuben Stewart).

Railroad curve tables; containing a comprehensive table of functions of a one-degree curve, with correction quantities giving exact values for any degree of curve, together with various other tables and formulas.

New York, Engineering News Publishing Co. 16mo, 3 + 69 pages. (Price : $1.)

1906 **621** .110

HOUGHTALING (W.).

The steam engine indicator and its appliances : being a comprehensive treatise for the use of constructing, erecting and operating engineers, superintendents, master mechanics, and students.

Bridgeport, Ct., American Industrial Publishing Co. 8vo, 11-307 pages, ill., diagrams. (Price : $2.)

1907 **721** .4

HOWE (Malverd A.), Professor of civil engineering of Rose polytechnic Institute.

Symmetrical masonry arches.

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The workings of railroads.

New York, Henry Holt & Co. (7 × 5 inches), cloth, 282 pages. (Price : $1.50.)

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PARSHALL (H. F.), M. Inst. C. E., & **HOBART** (H. M.), M. I. E. E.

Electric railway engineering.

London, Archibald Constable & Co. (Price : 42*s*.)

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WOOD (W. W.).

The Walschaert locomotive valve gear.

New York, Norman W. Henley Publishing Company. (7 $^1/_2$ × 5 inches), 185 pages, illustrated. (Price : $1.50.)

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6ª ediz. riveduta dall' ing. E. Garneri.

Torino, tip. lit. Societá editrice politecnica. 1 vol. in-8°, di 255 pagine e 132 figure in XII tav. (Prezzo : L. 3.50.)

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McPHERSON (Logan G.). — Le contrôle du gouvernement sur les chemins de fer aux États-Unis. (4,500 mots.)

1907 **621** .132.3 (.489)

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BUSSE (O.). — Locomotive express à quatre cylindres des chemins de fer de l'État danois. (1,800 mots, 1 tableau & fig.)

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Bulletin du Congrès des chemins de fer, nº 1, janvier, p. 23.

RAYMOND (William G.). — Problèmes de traction. (4,200 mots.)

1907 **621** .132.8

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HILD (F. W.). — L'automotrice à essence dans le service interurbain. (4,400 mots, 3 tableaux & fig.)

1907 **656** .211 & **656** .212

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TOLLER (E.). — Remaniement des gares de l'État saxon à Leipzig. (3,800 mots & fig.)

1907 **551** .51 & **621** .39

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GOLDSCHMIDT (R.). — Un anémomètre électrique. (1,150 mots & fig.)

1907 **625** .61 (01

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Influence des chemins de fer économiques sur les artères principales (question XVII, 7e session). Discussion. (5,900 mots.)

1907 **625** .611

Bulletin du Congrès des chemins de fer, nº 1, janvier, p. 71.

Concours financier donné par l'État et les localités intéressées pour développer les chemins de fer économiques (question XVIII, 7e session). Discussion. (17,000 mots.)

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Locomotives à marchandises compound duplex, système Mallet, du « Great Northern Railway » (États-Unis). (1,250 mots & fig.)

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Les services par omnibus automobiles organisés par le « London & North Western Railway ». (1,200 mots & fig.)

1907 **625** .143.1 & **625** .143.5

Bulletin du Congrès des chemins de fer, nº 1, janvier, p. 116.

Un rail qui supprime le cheminement. (450 mots.)

1907 **656** .281

Bulletin du Congrès des chemins de fer, nº 1, janvier, p. 117.

L'accident de Grantham. (3,800 mots & fig.)

1907 **016** .385. (02

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Bibliographie mensuelle des chemins de fer. — Livres. (42 fiches.)

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Bulletin de la Société d'encouragement pour l'industrie nationale. (Paris.)

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GUILLET (L.). — Aciers nickel-silicium. (3.600 mots, tableaux & fig.)

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PELLETAN (A.). — Les écoles techniques allemandes. (8,400 mots, 3 tableaux & fig.)

1906 **669** .1
Bull. de la Soc. d'enc. pour l'ind. nat., nº 4, décembre, p. 477.

OSMOND (F.). — Les expériences du professeur Heyn sur la trempe et le revenu des aciers. Leurs résultats et leurs conséquences. (2,500 mots, 4 tableaux & fig.)

1906 **669** .1
Bull. de la Soc. d'enc. pour l'ind. nat., nº 4, décembre, p. 491.

OSMOND (F.) & CARTAUD (G.). — Sur la cristallisation du fer. (10,000 mots & fig.)

1906 **62**. (01
Bull. de la Soc. d'enc. pour l'ind. nat., nº 4, décembre, p. 527.

LE CHATELIER (H.). — L'essai de dureté par la méthode de la bille de Brinell au Congrès de Bruxelles. (3,600 mots, 1 tableau & fig.)

Bulletin de la Société des ingénieurs civils de France. (Paris.)

1906 **669** .1
Bulletin de la Soc. des ing. civ. de France, novembre, p. 720.

GIROD (P.). — Fabrication des alliages ferro-métalliques au four électrique. (5,000 mots & fig.)

Génie civil. (Paris.)

1907 **656** .212.6
Génie civil, nº 1282, 5 janvier, p. 153.

Grue-tourelle de 150 tonnes à volée basculante du port de Tsing-tao (Chine). (1,500 mots & fig.)

1907 **721** .9
Génie civil, nº 1282, 5 janvier, p. 160.
— nº 1283, 12 — p. 177.

Circulaire ministérielle relative à l'emploi du béton armé. (5,000 mots, 1 tableau & fig.)

1907 **51** (08
Génie civil, nº 1283, 12 janvier, p. 182.

Cercle à calcul, système Halden. (300 mots & fig.)

Journal des transports. (Paris.)

1907 **621** .132.8
Journal des transports, nº 1, 5 janvier, p. 6.

Automotrices sur rails. (1,100 mots & 1 tableau.)

Portefeuille économique des machines. (Paris).

1907 **621** .116
Portefeuille économique des machines, nº 613, janvier, p. 1.

Les générateurs de vapeur Leroux. (3,000 mots & fig.)

Revue économique internationale. (Bruxelles.)

1907 **385** .15
Revue économique internationale, nº 1, janvier, p. 193.

BELLET (D.). — Chronique des transports. (5,000 mots.)

Revue générale des chemins de fer et des tramways. (Paris.)

1907 **625** .216
Revue générale des chemins de fer, nº 1, janvier, p. 3.

CHABAL & BEAU. — Dimensions à adopter pour les disques des tampons de choc des véhicules de chemins de fer à voie normale. (8,200 mots, tableaux & fig.)

1907 **725** .31
Revue générale des chemins de fer, nº 1, janvier, p. 36.

GOUNY. — Nouveaux types de bâtiments de voyageurs de la Compagnie de l'Est. (600 mots & fig.)

1907 **621** .132.3
Revue générale des chemins de fer, nº 1, janvier, p. 38.

DEMOULIN (M.). — Nouvelle locomotive Atlantic à deux bogies de l'État bavarois. (800 mots & fig.)

1907 **656** .257. (06.4
Revue générale des chemins de fer, nº 1, janvier, p. 42.

Exposition de Milan. Chemins de fer fédéraux suisses. Appareils d'enclenchements et de block-system. (3,000 mots & fig.)

1907 **621** .133.3 (01
Revue générale des chemins de fer, nº 1, janvier, p. 53.

Essais de plaques tubulaires en acier extra doux. (1,000 mots & fig.)

1907 **725** .33
Revue générale des chemins de fer, nº 1, janvier, p. 55.

Installation type de dépôt américain. (175 mots & fig.)

1907 **725** .33
Revue générale des chemins de fer, nº 1, janvier, p. 55.

Grue hydraulique de 10 mètres cubes à la minute. (350 mots & fig.)

In German.

nalen für Gewerbe und Bauwesen. (Berlin.)

07 **621** .132.8 (01
en für Gewerbe und Bauwesen, Nr 709, 1. Januar, p. 9.
GEL (R.). — Ergebnisse von vergleichenden Ver-
n mit Triebwagen und kleinen Lokomotiven.
Wörter & 3 Tabellen.)

07 **385**. (09.1 (.5)
en für Gewerbe und Bauwesen, Nr 710, 15. Januar, p. 21.
ESE. — Ueber einige Tropenbahnen Ostasiens.
0 Wörter & Fig.)

07 **621** .133.4
len für Gewerbe und Bauwesen, Nr 710, 15. Januar, p. 32.
UER. — Ausblasevorrichtung für die Rauchkam-
ösche von F. H. Trevithick. (500 Wörter & Fig.)

Archiv für Eisenbahnwesen. (Berlin.)

07 **385** .14 (.73)
iv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 1.
EYER (B. H.). — Das neue Bundeseisenbahngesetz
n Vereinigten Staaten. (17,000 Wörter.)

07 **385** .517 (.431)
iv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 47.
JDLIN. — Wohlfahrtseinrichtungen der preussisch-
schen Eisenbahngemeinschaft im Jahre 1905. (9,200
ter & Tabellen.)

07 **385** .15 (.436)
iv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 136.
OLFF. — Der Erwerb der österreichischen Kaiser
linands-Nordbahn für den Staat. (12,000 Wörter.)

07 **313** .385 (.43 + .42 + .44)
iv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 169.
e Eisenbahnen Deutschlands, Englands und Frank-
hs in den Jahren 1901 bis 1903. (Tabellen.)

07 **313** .385 (.432)
iv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 187.
ie unter königlich sächsischer Staatsverwaltung
enden Staats- und Privateisenbahnen im Jahre 1905.
ellen.)

1907 **313** .385 (.436)
Archiv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 205.

Hauptergebnisse der österreichischen Eisenbahnstatistik für das Jahr 1904. (Tabellen.)

1907 **313** .385 (.44)
Archiv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 220.

Die Eisenbahnen in Frankreich im Jahre 1903. (Tabellen.)

1907 **313 : 656** .28 (.44)
Archiv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 226.

Unfälle auf den französischen Eisenbahnen in den Jahren 1902 und 1903. (Tabellen.)

1907 **313** .385 (.54)
Archiv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 232.

Die Eisenbahnen Britisch-Ostindiens im Kalenderjahr 1905. (Tabellen.)

1907 **313** .385 (.82)
Archiv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 240.

Hauptergebnisse der argentinischen Eisenbahnen für die Jahre 1903 und 1904. (Tabellen.)

1907 **385** .113 (.496)
Archiv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 255.

Die orientalischen Eisenbahnen im Jahre 1905. (Tabellen.)

1907 **313** .385 (.47)
Archiv für Eisenbahnwesen, Heft 1, Januar-Februar, p. 272.

Statistisches von den Eisenbahnen Russlands. (Tabellen.)

Beton und Eisen. (Berlin.)

1907 **624** .63
Beton und Eisen, Heft 1, p. 5.

NOWAK (A.). — Der Eisenbetonbau bei den neuen, durch die k. k. Eisenbahnbaudirektion hergestellten Bahnlinien der österreichischen Monarchie. (900 Wörter, 2 Tabellen & Fig.)

1907 **721** .9 (01
Beton und Eisen, Heft 1, p. 14.

MASEREEUW (H.). — Versuch mit einer Platte aus Betoneisen für einen Tunnel im Rangierbahnhofe der Holländischen Eisenbahn-Gesellschaft zu Watergraafsmeer bei Amsterdam. (800 Wörter, Tabellen & Fig.

07 **721** .9
und Eisen, Heft 1, p. 20.
IMOVICI (E.). — Zur Frage : Wie kann die Anwen-
des Eisenbetons in der Eisenbahnverwaltung
tlich gefördert werden? (1,400 Wörter & Fig.)

Bulletin des internationalen Eisenbahn-Kongress-Verbandes. (Brüssel.)

07 **385** .14 (.73)
tin des Eisenbahn-Kongresses, Nr 1, Januar, S. 3.
PHERSON (Logan G.). — Staats-Aufsicht über
Eisenbahnen in den Vereinigten Staaten. (4,600
ter.)

07 **625** .216
tin des Eisenbahn-Kongresses, Nr 1, Januar, S. 15.
YEN (J.). — Die Buffer während des Rangierens
Bremsens langer Züge. (1,400 Wörter & Abb.)

07 **625** .144.4
tin des Eisenbahn-Kongresses, Nr 1, Januar, S. 23.
HLÜSSEL (L.). — Die Lockerung der Schrau-
erbindungen im Eisenbahngleise. (6,200 Wörter
bb.)

07 **656** .211 & **656** .212
tin des Eisenbahn-Kongresses, Nr 1, Januar, S. 45.
LLER (E.). — Umbau der Bahnhöfe Leipzig,
sischer Teil. (3,500 Wörter & Abb.)

07 **625**. 143.3
tin des Eisenbahn-Kongresses, Nr 1, Januar, S. 54.
OYLE (G.). — Dröhnende Eisenbahnschienen
ring Rails). (2,500 Wörter & Abb.)

07 **625** .143.4
tin des Eisenbahn-Kongresses, Nr 1, Januar, S. 62.
serne Doppelstossschwellen als tadellose Stossan-
ung und beste Verhütung des Wanderns der Schienen.
00 Wörter, 1 Tabelle & Abb.)

07 **625** .143.2
etin des Eisenbahn-Kongresses, Nr 1, Januar, S. 68.
hosphor in Stahlschienen. (1,800 Wörter.)

07 **625** .144.1
etin des Eisenbahn-Kongresses, Nr 1, Januar, S. 71.
rösste Schienenlänge auf der freien Strecke bei den
en französischen Eisenbahnen. (600 Wörter.)

1907 **625** .143.5
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 73.

Versuche mit der Lakhovskyschen Schwellenschraube. (2,000 Wörter & Abb.)

1907 **625** .245
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 84.

Wagen von 40 Tonnen Tragfähigkeit für die Beförderung von Dampfkesseln, grossen Gussstücken und schweren Maschinen auf den Strecken der Cheshire Eisenbahn. (250 Wörter & Abb.)

1907 **621** .14 (09.3 (.42)
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 84.

Strassen-Kraftwagen-Verkehr in England. (1,450 Wörter & Abb.)

1907 **621** .131.2
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 89.

Grenzen für den Achsdruck. (1,150 Wörter.)

1907 **625** .251
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 92.

Bremsdruckreglung nach Massgabe der Belastung. (1,150 Wörter.)

1907 **656** .211.5
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 94.

Butterfly canopy (Ueberdachung in Schmetterlingsform) auf den Bahnsteigen der New-York Central-Eisenbahn. (500 Wörter & Abb.)

1907 **656** .215
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 96.

Die Beleuchtung der Viktoria-Station. (500 Wörter & Abb.)

1907 **656** .261
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 98.

Die Expressgesellschaften der Vereinigten Staaten. (1,400 Wörter.)

1907 **621** .133.7
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 101.

Wasserschaufel an Tendern der « Great Eastern Railway ». (600 Wörter & Abb.)

1907 **016** .385. (02
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 1.

Monatliches Verzeichnis der Eisenbahnliteratur. — Bücher. (42 Zettel.)

1907 **016** .385. (05
Bulletin des Eisenbahn-Kongresses, Nr 1, Januar, S. 5.

Monatliches Verzeichnis der Eisenbahnliteratur. — Zeitschriften. (222 Zettel.)

Œsterreichische Eisenbahn-Zeitung. (Wien.)

1907 **656** .256.3 & **625** .4
Œsterreichische Eisenbahn-Zeit., Nr 1, 7. Jänner, p. 1.

KOHLFÜRST (L.). — Die Zugsicherungseinrichtungen der Londoner Distriktsbahnlinien. (1,900 Wörter & Fig.) (S. *Bulletin du Congrès des chemins de fer*, nº 12, décembre 1906.)

1907 **385** .517.6
Œsterreichische Eisenbahn-Zeit., Nr 2, 14. Jänner, p. 12.

BÉKÉSS (A.). — Ueber Seh- und Farbenprüfung im Eisenbahndienst. (1,600 Wörter.)

1907 **656** .234 (.43)
Œsterreichische Eisenbahn-Zeit., Nr 3, 21. Jänner, p. 17.

ANGEL (E.). — Die Personentarifreform in Deutschland. (1,100 Wörter & 1 Tabelle.)

Elektrische Bahnen und Betriebe. Zeitschrift für Verkehrs- und Transportwesen. (München.)

1907 **621** .33 (.73)
Elektrische Bahnen u. Betriebe, Heft 2, 14. Januar, p. 21.

EICHEL (E.). — Ueber einige Eigentümlichkeiten der elektrischen Bahnen in den Vereinigten Staaten. (1,500 Wörter & Fig.)

1907 **621** .331
Elektrische Bahnen u. Betriebe, Heft 3, 24. Januar, p. 41.

KÖSTER (F.). — Das Kraftwerk Pennsylvania in Long Island-City der Pennsylvania, New York and Long Island Railroad Company. (3,600 Wörter & Fig.)

Organ für die Fortschritte des Eisenbahnwesens in technischer Beziehung. (Wiesbaden.)

1907 **621** .132.3 (.489)
Organ für die Fortschritte des Eisenbahnw., 1. Heft, p. 1.

BUSSE (O.). — $^2/_5$ gekuppelte Vierzylinder-Schnellzug-Verbund-Lokomotive für die dänischen Staatsbahnen. (1,600 Wörter, 4 Tabellen & Fig.)

1907 **621** .32 & **621** .8
Organ für die Fortschritte des Eisenbahnw., 1. Heft, p. 7.

LENZ. — Die elektrischen Kraft-und Licht-Anlagen der neuen Lokomotiv-Werkstätte auf dem Bahnhofe Dortmund-Rgb. (1,700 Wörter & Fig.)

1907 **625** .143.4
Organ für die Fortschritte des Eisenbahnw., 1. Heft, p. 9.

HROMATKA (F.). — Der Schienenstoss von Wolhaupter. (550 Wörter & Fig.)

1907 **313** : **625** .62 (.43 + .494 + .44)
Organ für die Fortschritte des Eisenbahnw., 1. Heft, p. 10.

KRULL (F.). — Die Betriebsergebnisse der deutschen, schweizerischen und französischen Strassenbahnen. (800 Wörter & 1 Tabelle.)

1907 **725** .33
Organ für die Fortschritte des Eisenbahnw., 1. Heft, p. 12.

ZIMMERMANN (F.). — Der Bau neuer Lokomotivschuppen. (1,800 Wörter & 1 Tabelle.)

1907 **621** .33 & **625** .13
Organ für die Fortschritte des Eisenbahnw., 1. Heft, p. 14.

CSERHÁTI (E.). — Elektrischer Betrieb im Simplon Tunnel. (250 Wörter & Fig.)

1907 **625** .175
Organ für die Fortschritte des Eisenbahnw., 1. Heft, p. 16.

Untersuchungswagen für den Simplon-Tunnel. (250 Wörter & Fig.)

1907 **624** .63
Organ für die Fortschritte des Eisenbahnw., 1. Heft, p. 17.

Straussche Eisenbetonbrücke für die elektrische Bahn Elgin-Belvidere. (1,100 Wörter & Fig.)

1907 **621** .137.3
Organ für die Fortschritte des Eisenbahnw., 1. Heft, p. 21.

Lokomotivbesetzungen. (600 Wörter.) (S. *Bulletin du Congrès des chemins de fer*, nº 7, juillet 1906.)

Schweizerische Bauzeitung. (Zürich.)

1907 **656** .255 & **656** .256
Schweizerische Bauzeitung, Nr 1, 5. Januar, p. 12.
— — Nr 4, 26. — p. 50.

TOBLER (A.). — Zwei bemerkenswerte Schaltungen zur Sicherung des Bahnbetriebes (3,200 Wörter & Fig.)

Zeitschrift für Kleinbahnen. (Berlin.)

1907 **388** (.73)
Zeitschrift für Kleinbahnen, Heft 1, Januar, p. 1.

GIESE (E.) & BLUM. — Beiträge zur Frage des Nahverkehrs in Nordamerika. (4,000 Wörter & Fig.)

1907 **313 : 625** .61 (.439)
Zeitschrift für Kleinbahnen, Heft 1, Januar, p. 13.

NAGEL (R.). — Die Lokalbahnen Ungarns im Jahre 1904. (400 Wörter & Tabellen.)

Zeitschrift des Vereines deutscher Ingenieure. (Berlin.)

1907 **621** .134.3
Zeit. des Vereines deutscher Ingenieure, Nr 1, 5. Januar, p. 11.

SAUER (E.). — $^2/_4$ gekuppelte Personenzuglokomotive mit Speisewasservorwärmern. (4,800 Wörter, 1 Tabelle & Fig.)

1907 **385**. (01 (.51)
Zeit. des Vereines deutscher Ingenieure, Nr 2, 12. Januar, p. 41.

WENZ (A.). — Allgemeines und Technisches vom Bau der Schantungbahn. (2,700 Wörter & Fig.)

1907 **656** .221
Zeit. des Vereines deutscher Ingenieure, Nr 3, 19. Januar, p. 94.

FRANK (A.). — Die Widerstände der Eisenbahnzüge und die zu ihrer Berechnung dienenden Formeln. (4,500 Wörter & 2 Tabellen.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1907 **625** .233
Zeitung des Vereins, Nr 2, 9. Januar, p. 21.

WEDLER. — Die Gasglühlichtbeleuchtung der Eisenbahnwagen. (1,600 Wörter.)

1907 **656** .234 (.45)
Zeitung des Vereins, Nr 3, 12. Januar, p. 37.

SCHULZE (W.-A.). — Der neue italienische Eisenbahn-Personentarif. (2,000 Wörter.)

1907 **385** .524 & **385** .581
Zeitung des Vereins, Nr 6, 23. Januar, p. 89.
— Nr 7, 26. — p. 105.

HEUBACH. — Soziale und finanzielle Probleme für Eisenbahnverwaltungen, insbesondere die Gewinnbeteiligung des Personals. (6,500 Wörter & 2 Tabellen.)

Zentralblatt der Bauverwaltung. (Berlin.)

1907 **625** .13
Zentralblatt der Bauverwaltung, Nr 1 u. 2, 2. Januar, p. 9.

HEINRICH. — Die Verlegung der Parthe auf dem Hauptbahnhof Leipzig. (2,200 Wörter & Fig.)

1907 **624** .8
Zentralblatt der Bauverwaltung, Nr 3, 5. Januar, p. 17.

RICHTER. — Neuere Klappbrücken in Königsberg i. Pr. (1,200 Wörter & Fig.)

1907 **656** .211.2
Zentralblatt der Bauverwaltung, Nr 7, 19. Januar, p. 55.

BALTZER (F.). — Die Herstellung von Ueberholungsgleisen beim zweigleisigen Streckenausbau. (900 Wörter & Fig.)

In English.

American Engineer and Railroad Journal. (New York.)

1907 **621** .335
American Engineer & R. Journal, No. 1, January, p. 1.

2-8-2 type electric locomotive. (2,200 words & fig.)

Bulletin of the International Railway Congress Association. (Brussels.)

1907 **625** .144.4
Bulletin of the Railway Congress, No. 1, January, p. 3.

SCHLÜSSEL (L.). — Note on the working loose of screws when used as rail-fastenings. (6,500 words & fig.)

1907 **624** .32
Bulletin of the Railway Congress, No. 1, January, p. 24.

MARRIOTT (William) & GRIBBLE (Theodore Graham). — The Breydon viaduct at Great Yarmouth. (4,500 words & fig.

1907 **625** .251
Bulletin of the Railway Congress, No. 1, January, p. 44.

FOWLER (Geo. L.). — Test of the Sauvage air brake. (5,100 words, 2 tables & fig.)

1907 **621** .133.2
Bulletin of the Railway Congress, No. 1, January, p. 58.

Flexible stay bolts. (4,600 words & fig.)

1907 **385** .517

Bulletin of the Railway Congress, No. 1, January, p. 67.

Provident institutions (question XVI, 7th session). Discussion. (18,300 words & 3 tables.)

1907 **385** .517

Bulletin of the Railway Congress, No. 1, January, p. 108.

RIEBENACK (M.). — Provident institutions (question XVI, 7th session). 2nd supplement to report No. 1. Appendix to the discussion. (1,900 words & 1 table.)

1907 **385** .517 (.942)

Bulletin of the Railway Congress, No. 1, January, p. 113.

PICKERING (John). — Provident institutions (question XVI, 7th session). Note on the provident institutions of the South Australian State Railways. Appendix to the discussion. (2,100 words & 3 tables.)

1907 **621** .132.5

Bulletin of the Railway Congress, No. 1, January, p. 121.

Mallet duplex compound freight locomotives for the Great Northern Railway (United States). (1,000 words & fig.)

1907 **625** .143.1 & **625** .143.5

Bulletin of the Railway Congress, No. 1, January, p. 125.

A non-creeping rail. (450 words & fig.)

1907 **625** .251

Bulletin of the Railway Congress, No. 1, January, p. 126.

Obstruction in brake pipe. (250 words.)

1907 **625** .253

Bulletin of the Railway Congress, No. 1, January, p. 127.

Percentage of freight cars equipped with airbrakes in the United States. (250 words.)

1907 **656** .281

Bulletin of the Railway Congress, No. 1, January, p. 127.

The Grantham accident. (3,400 words & fig.)

1907 **385**. (09.2

Bulletin of the Railway Congress, No. 1, January, p. 137.

Obituary : Samuel SPENCER. (3,200 words & portrait.)

1907 **016** .385. (02

Bulletin of the Railway Congress, No. 1, January, p. 1.

Monthly bibliography of railways. — Books. (42 labels.)

1907 **016** .385. (05

Bulletin of the Railway Congress, No. 1, January, p. 5.

Monthly bibliography of railways. — Periodicals. (222 labels.)

Engineer. (London.)

1907 **621** .132.1 (.42

Engineer, No. 2662, January 4, p. 14.

Locomotive engines. (2,700 words.)

1907 **624** .52

Engineer, No. 2664, January 18, p. 54.

The Quebec bridge. (1,200 words & fig.)

1907 **621** .132.4

Engineer, No. 2665, January 25, p. 84.

Four new British locomotives. (800 words & fig.)

Engineering. (London.)

1907 **621** .132.6

Engineering, No. 2140, January 4, p. 12.

Ten-wheel coupled locomotive with Schmidt superheater. (700 words & fig.)

1907 **656** .283

Engineering, No. 2140, January 4, p. 13.

The collision at Elliot junction, North British Railway. (600 words & fig.)

1907 **621** .33 & **625** .4

Engineering, No. 2141, January 11, p. 38.

The Paris Metropolitan Railway. (2,000 words & fig.)

Engineering Magazine. (London.)

1907 **621** .7

Engineering Magazine, January, p. 481.

CARPENTIER (C. U.). — Profit-making in shop and factory management. (4,400 words.)

1907 **621** .7

Engineering Magazine, January, p. 523.

JACOBS (H. W.). — Organization and economy in the railway machine shop. (4,000 words & fig)

Engineering News. (New York.)

1907 **621** .133.1

Engineering News, No. 2, January 10, p. 33.

The use of oil fuel for locomotives. (2,800 words & fig.)

1907 **621** .134.3

Engineering News, No. 2, January 10, p. 35.

Are high steam pressures for locomotives advantageous? (5,500 words.)

Journal of the Western Society of Engineers. (Chicago.)

1906 388 & 625 .13
Journal of the Western Society of Engin., No. 5, October, p. 576.

ROBINSON (A. S.). — The proposed "Inner circle" system of Chicago subway terminals. (17,000 words & fig.)

Locomotive Journal. (Leeds.)

1907 625 .14 (01 & 625 .2 (01
Locomotive Journal, No. 1, January, p. 1.

Railway safety, from the rolling-stock, speed limit, and permanent-way side of the question. (2,700 words, 2 tables & fig.)

Page's Weekly. (London.)

1906 669 .1
Page's Weekly, No. 120, December 28, p. 1425.

HIORNS (A. H.). — Combined influence of certain elements on cast-iron. (3,600 words & fig.)

1907 621 .14
Page's Weekly, No. 124, January 25, p. 166.

The Renard road train system. (1,600 words & fig.)

Railroad Gazette. (New York.)

1906 625 .174
Railroad Gazette, No. 26, December 28, p. 578.

Rotary snow plows on the Denver, Northwestern & Pacific. (300 words & fig.)

1906 625 .13
Railroad Gazette, No. 26, December 28, p. 582.

The Pennsylvania tunnels under the North River. (3,200 words & fig.)

1907 385 .581 (.73)
Railroad Gazette, No. 1, January 4, p. 3.

Trainmen's hours of labor. (2,400 words.)

1907 621 .132.4
Railroad Gazette, No. 1, January 4, p. 10.

Mogul locomotive for the Vandalia. (900 words & fig.)

1907 625 .232
Railroad Gazette, No. 1, January 4, p. 17.

Steel passenger car for the Long Island Railroad. (600 words & fig.)

1907 385. (09.2
Railroad Gazette, No. 1, January 4, p. 20.

Alexander Johnston Cassatt. (1,400 words & portrait.)

1907 388 (.73)
Railroad Gazette, No. 1, January 4, p. 22.

Rapid transit lines in New York City. (3,200 words & fig.)

1907 621 .132.4 & 621 .132.5
Railroad Gazette, No. 2, January 11, p. 50.

Locomotives for the Italian Government Railways. (450 words & fig.)

1907 62. (01
Railroad Gazette, No. 3, January 18, p. 70.

Tests of bond between concrete and steel. (1,700 words & fig.)

1907 656 .283
Railroad Gazette, No. 3, January 18, p. 76.

Government investigation of the Terra Cotta collision. (2,700 words.)

1907 656 .256.3
Railroad Gazette, No. 3, January 18, p. 80.

Automatic block signals on the Baltimore & Ohio. (600 words & fig.)

1907 621 .133.4
Railroad Gazette, No. 4, January 25, p. 110.

Timmis smoke and spark consuming system. (400 words & fig.)

1907 621 .131.2
Railroad Gazette, No. 4, January 25, p. 116.

National characteristics in locomotive building. (2,800 words.)

Railway Age. (Chicago.)

1906 625 .246
Railway Age, No. 1594, December 28, p. 826.

Steel cars from the Middletown car works. (900 words & fig.)

1907 725 .33
Railway Age, No. 1595, January 4, p. 8.

East Decatur shops of the Wabash. (2,000 words & fig.)

1907 625 .232
Railway Age, No. 1596, January 11, p. 47.

Steel coach for the Southern Pacific. (600 words & fig.)

1907 625 .13
Railway Age, No. 1597, January 18, p. 72.

The Eastern Railway of New Mexico. (2,000 words & fig.)

Railway Engineer. (London.)

1907 621 .132.4
Railway Engineer, No. 324, January, p. 4.

New 4-6-0 type engines; Great Central Railway. (250 words & fig.)

1907 625 .232
Railway Engineer, No. 324, January, p. 7.

New Pullman buffet and parlour cars, London, Brighton and South Coast Railway. (400 words & fig.)

1907 656 .257
Railway Engineer, No. 324, January, p. 9.

Union Switch & Signal Co.'s switch controller. (400 words & fig.)

1907 656 .255
Railway Engineer, No. 324, January, p. 24.

Electric occupation system for single lines. (3,200 words & fig.)

Railway and Engineering Review. (Chicago.)

1906 725 .33
Railway and Engineering Review, No. 52, December 29, p. 1013.

CAMPBELL (J. L.). — El Paso & Southwestern Railway shops. (2,000 words & fig.)

1906 656 .256
Railway and Engineering Review, No. 52, December 29, p. 1016.

Remedy for foreign current on automatic block signals. (4,500 words & fig.)

1906 625 .13
Railway and Engineering Review, No. 52, December 29, p. 1020.

Ventilation of the Boston subway. (1,800 words.)

1906 621 .132.3
Railway and Engineering Review, No. 52, December 29, p. 1022.

New locomotives for National Railways of Mexico. (1,200 words & fig.)

1906 656 .223.2
Railway and Engineering Review, No. 52, December 29, p. 1025.

Car clearing houses, car pools, etc. (8,000 words & 2 tables.)

1907 725 .33
Railway and Engineering Review, No. 1, January 5, p. 3.

Modernizing engine terminals on the B. & O. R. R. (2,400 words & fig.)

1907 656 .222.1
Railway and Engineering Review, No. 2, January 12, p. 23.

Tonnage rating of engines. (1,300 words.)

1907 656 .222.6
Railway and Engineering Review, No. 2, January 12, p. 33.

Interurban freight and express. (3,300 words.)

1907 725 .31
Railway and Engineering Review, No. 3, January 19, p. 44.

New Union station at Seattle. (550 words & fig.)

Railway Gazette. (London.)

1907 656 .222.6 (.42)
Railway Gazette, No. 1, January 4, p. 8.

Watching the freight traffic by daily returns British Railways. (1,700 words & 1 table.)

1907 656 .222.6 (.73)
Railway Gazette, No. 1, January 4, p. 9.

Watching the freight traffic by daily returns American Railroads. (1,200 words & 2 tables.)

1907 625 .616 (.52)
Railway Gazette, No. 1, January 4, p. 16.

Compound locomotive for the Kansel Railway, Japan. (800 words & fig.)

1907 625 .122
Railway Gazette, No. 1, January 4, p. 17.

SESSER (J. C.). — Cost of steam shovel work. (2,000 words.)

1907 621 .132.8
Railway Gazette, No. 2, January 11, p. 31.

New rail motor trains, London & South Western Railway. (400 words & fig.)

1907 625 .13
Railway Gazette, No. 2, January 11, p. 38.

The Pennsylvania tunnels under the North River. (3,200 words & fig.)

1907 621 .132.8
Railway Gazette, No. 3, January 18, p. 54.

RICHES (T. H.) & HASLAM (S. B.). — Railway motor car traffic. (2,600 words, 3 tables & fig.)

1907 388 (.73)
Railway Gazette, No. 3, January 18, p. 66.

Rapid transit lines in New York City. (3,200 words & fig.)

1907 625 .142.2
Railway Gazette, No. 4, January 25, p. 85.

Cross-tie conditions in some foreign countries. (3,700 words.)

Railway Machinery. (New York.)

1907 621 .132.8
Railway Machinery, January, p. 231.

KING (C. R.). — Four-cylinder balanced engine railway motor car. (700 words & fig.)

Railway Magazine. (London.)

1907 656 .222.1 (.42)
Railway Magazine, No. 115, January, p. 18.

ROUS-MARTEN (C.). — British locomotive practice and performance. (3,000 words & fig.)

1907 656 .222.1 (.42)
Railway Magazine, No. 115, January, p. 37.

CHARLEWOOD (R. E.). — London and North Western Railway expresses in 1906. (3,700 words & fig.)

1907 621 .132.8 (.42)
Railway Magazine, No. 115, January, p. 56.

Motor traction on the London and South Western Railway. (1,000 words & fig.)

Railway Master Mechanic. (Chicago.)

1907 725 .33
Railway Master Mechanic, No. 1, January, p. 5.

Roundhouse with crane service, Denver & Rio Grande R. R. (1,000 words & fig.)

1907 621 .132.8
Railway Master Mechanic, No. 1, January, p. 19.

Four-cylinder simple locomotive—L. S. & M. S. Ry. (500 words & fig.)

Statist. (London.)

1907 385 .113 (.73)
Statist, No. 1509, January 26, p. 171.

American railways. What do they earn and pay? (2,300 words.)

Street Railway Journal. (New York.)

1907 388 (.73)
Street Railway Journal, No. 1, January 5, p. 8.

The East side-Bronx transportation question of New York City. Proposed remedies. (2,200 words & fig.)

1907 388 (.73) & 621 .338 (.73)
Street Railway Journal, No. 1, January 5, p. 14.
— — No. 3, — 19, p. 90.

FOX (J. P.). — Suggestions on rapid transit with particular reference to rolling stock. (11,500 words, tables & fig.)

1907 625 .143.4
Street Railway Journal, No. 2, January 12, p. 59.

FRENCH (M. J.). — Thermit rail-welding—Experiences of the Utica & Mohawk Valley Railway Company. (2,700 words & fig.)

Tramway & Railway World. (London.)

1907 621 .33 (09.1 (.42)
Tramway & Railway World, January, p. 9.

Birmingham Corporation Tramways. 5,500 words & fig.)

In Italian

Bollettino della Societá degli ingegneri e degli architetti italiani. (Roma.)

1906 625 .11 (.45 + .494)
Boll. del. Soc. degli ing. e deg. arch. it., nº 51/52, 30 dic., p. 749.

Pro Spluga. (10,500 parole, 1 tavole & fig.)

Giornale del genio civile. (Roma.)

1906 625 .111 & 625 .13
Giornale del genio civile, dicembre, p. 648.

La galleria del Sempione e le sue linee di accesso. (14,000 parole, 1 tavole & fig.)

Ingegneria ferroviaria. (Roma.)

1907 625 .11 (.494 + .45)
Ingegneria ferroviaria, nº 1, 1º gennaio, p. 2.
— — nº 2, 16 — p. 18.

La domanda del Canton Grigioni per la ferrovia dello Spluga. (5,000 parole, tavole & fig.)

1907 625 .151
Ingegneria ferroviaria, nº 1, 1º gennaio, p. 11.

Apparecchi di sicurezza per deviatoi. (850 parole & fig.)

1907 621 .335 & 621 .338
Ingegneria ferroviaria, nº 1, 1º gennaio, p. 12.

Le automotrici ed i treni ad unità multiple delle ferrovie Varesine. (1,400 parole & fig.)

1907 621 .132.6

Ingegneria ferroviaria, nº 2, 16 gennaio, p. 25.

Alcune recenti locomotive a vapore soprariscaldato dello Stato prussiano. (1,100 parole & fig.)

In Spanish.

Gaceta de los caminos de hierro. (Madrid.)

1907 313 .385 (.4)

Gaceta de los caminos de hierro, nº 2627, 24 de enero, p. 43.

Los ferrocarriles de Europa en 1906. (1,000 palabras & 3 cuadros.)

In Dutch.

Ingenieur. ('s Gravenhage.)

1907 625 .13

Ingenieur, nr 1, 5 Januari, p. 2.

FRANÇOIS (H. N.). — De nieuwe Hembrug over het Noordzeekanaal en de daarmede in verband staande omlegging van den spoorweg Helder-Amsterdam. (6,000 woorden & fig.)

1907 625 .111

Ingenieur, nr 4, 26 Januari, p. 67.

NIERSTRASZ (N. H.). — Spoorwegverbindingen om Amsterdam. (15,000 woorden, 5 tafereelen & fig.)

Vol. XXI. — No. 4. April, 1907. 12th Year of the English Edition.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[625 .14 (01]

NOTE

ON THE ECONOMIC RENEWAL AND MAINTENANCE OF RAILWAV TRACKS FOR HIGH SPEED TRAFFIC.

EXAMINATION OF A VIGNOLES TRACK, WITH CRAMPS, WEDGES AND SHOCK-ABSORBER OR DEADENER BLOCKS,

By L. SCHLÜSSEL,
CIVIL ENGINEER, PARIS.

Figs. 1 to 7, pp. 384 to 409.

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I. Scope of this examination. — II. General considerations on rail-fastenings. — III. Capacity limit of the proposed track. — IV. Determination of the destructive forces possible in the case of the assumed capacity. — V. Constitution, shape and strength of the constituent parts of the track. — VI. Design of the fastenings. — VII. Economy. — VIII. Conclusion.

I. — Scope of this examination.

The investigation of tracks able to stand high speeds is necessary, as all the main railways are carrying traffic which is continually growing. On some lines of limited capacity the possible maximum will soon be reached.

Such investigation, in our opinion, becomes necessary because the premises made at the time railway construction was first begun have since been proved by experience to be deficient. The modifications subsequently made to enable the lines to be used for higher speeds, have only been successive and partial improvements affecting most frequently the rails, sometimes the sleepers and the ballast, rarely the fastenings, *but never these constituent parts considered as a whole, with their proper connection.*

Such an investigation is however of the greatest importance, as the renewal of tracks and their maintenance represent annually very large sums which have to be provided; it affects one of the great economic problems of the present period : we mean the proper handling of the huge capital sums invested in railway undertakings.

Every attempt made in order to reduce the expenses, whoever may make it, is but the more valuable and useful, if it is based on experiments undertaken and if the results are reported to the International Railway Congresses. It is at least a step in the right direction, which cannot be looked upon with indifference, at it is a question affecting the financial economy of capital sums tending, in different ways, to become more and more the common heritage of the inhabitants of the different countries.

Some of the constituent parts of the track have been studied very frequently; such investigations have led the companies to replace the old rails by heavier rails, the old sleepers by stronger and more suitable sleepers, and to adopt better ballasting; *but the proper connection of these constituent parts, which give the proper cohesion and stiffness which are so essential for smooth running,* has remained in the background. Even at present we still use spikes which are recognized to be unsatisfactory, and screws which cannot keep the fastenings tight for any length of time.

It might be that bolts and screws, at present nearly the only things used, produced actually a tight connection, though a weak one; but it is universally recognized in the reports made to the different sessions of the Railway Congress, that these fastenings, which though small in size have very important functions, are quite incapable of maintaining a proper pressure between the constituent parts of a railway track and that they only hold them together imperfectly, *allowing the rails to lift, to cant and to creep;* and this, quite apart from the question of possible accident, makes maintenance exceedingly expensive.

Now unless there is constant pressure, no fastening remains tight; hence the importance of obtaining such pressure. And it can be obtained neither by the spike nor by the screw in its various forms (screwspikes, bolts and nuts), when acted on by unsymmetrical forces, the only forces acting on railway tracks (1).

Attempts have already been made to construct tracks suitable for high speeds. The H. Michel sleeper, now being laid on the Paris-Lyon-Mediterranean Railway, is one of the most recent; but here again the fastening adopted is the screwspike which is condemned by experience and which is damaged by the wrench used to drive it in, so that it is incapable of resisting the forces. Neither the number nor the length of the screwspikes will protect them against the unsymmetrical forces produced by the rolling loads, forces which increase with the speed.

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(1) See *Bulletin of the Railway Congress*, No. 1, January, 1907, p. 3 : « Note on the working loose of screws when used as rail-fastenings », by L. Schlüssel, Paris.

Moreover, the complexity of the means proposed, although of much interest, does not induce us to think that the problem will be resolved in such a way. It is indeed a resolution of the same problem we are going to propose, taking as our bases the results submitted to and discussed at the different sessions of the Railway Congress.

A track acted on by rolling stock in movement cannot be considered as an anvil subjected to the repeated blows of a hammer; if this were so the rolling stock would soon be destroyed.

It is allowed that a track should act as a long spring, capable of taking up, *equally at every point over its length,* the forces which result from the moving loads which the track supports and guides.

If the running is to be smooth, the forces must be taken up progressively and without impact; the absorption must be effected by the diminishing elasticity of the constituent parts of the track.

But here there is a difference of opinion. Some think the dynamic forces should be absorbed chiefly in the superstructure; others that this should take place in the foundation, that is to say, by the ballast and the ground with which the superstructure should form one whole.

In the first case, the ends of the undisturbed sleepers rest on the ballast; when a rolling load approaches, the sleepers are first raised slightly, and then progressively depressed, absorbing part of the dynamic forces and transmitting, without impact, the rest of these forces to the ground, through the elastic ballast itself. Hence it is necessary to use long and flexible sleepers (2·7 metres [8 ft. 10 $^5/_{16}$ in.]); this condition is fairly well satisfied by the wooden sleeper now used, when it supports the load over its whole length. We say fairly well satisfied, at least for a limited period of time; for those fibres of the wooden sleeper which are most strained are just those which are destroyed most quickly by the action of the weather.

But this bending of the sleeper makes the track narrower on the straight and wider on curves; the dynamic forces in all directions are thereby increased. The quick displacement of the fastenings, already facilitated by the unsatisfactory nature of the fastenings, and a very limited distribution of the vertical loads on material unable to support them, make the maintenance of such a track very costly, in spite of the use of bed-plates which however were a distinct step in advance.

The use of metal sleepers laid in a similar manner has not become at all extended. Although they have the distinct advantage of a longer life, there are the disadvantages of having deficient screw fastenings not of sufficient strength, the fibres are overstrained during the pressing of the sleeper, the sleeper has to be stronger in the middle, the arrangement is generally complicated and there is the noisiness inherent to any fastenings in which metal rests on metal, and that without adhesion. In fact only about one-tenth of the railway tracks are laid with metal sleepers.

In the second case, in which the forces produced by the rolling loads are to be absorbed by the elastic ballast direct, the sleepers, even in a state of rest, must be as well on their packing, a limited packing, and the distance between the rails must be kept constant by the use of a stiff sleeper which becomes depressed uniformly over its whole length. Hence short and stiff sleepers (2·2 metres [7 ft. 2 $^5/_8$ in.]) with great resistance to bending; and these used in conjunction with heavy rails and supported joints enable us to obtain a track everywhere much stiffer than one with long and flexible sleepers; the elasticity of the latter result in sinusoidal displacement when quickly moving rolling stock approaches.

Which is the better of these two systems?

We have the advantage of a long experience in the case of the first only, but this experience tells us that this system however carefully applied, results in costly maintenance and in any case is not satisfactory for the higher speeds which we have to expect, as even at present the constituent parts are subjected to greater stress and more fatigue than the material used should be subjected to.

Will the second system in practice give the results which are expected?

Although some trials justify the use of short sleepers, there is no evidence to show that as now used there will be sufficient cohesion with the ballast at higher speeds.

As basis in making our selection, let us take experience and nothing else.

The work submitted to the different sessions of the Congress has shown that if an axle is so loaded, and the static wheel-load is P, the same axle *if moving*, produces vertical forces varying between 2·4P and $\frac{P}{4}$, according to the state of the track and the rolling stock (two factors which must be improved simultaneously), and that the upper limit 2·4P may become reduced to 1·2P on a rigid track ([1]).

If the dynamic part of the forces, the excess over the static load P, produced by the movement, can be reduced from 1·4P to 0·2P, *as far as the track is concerned,* by greater stiffness, though not absolute rigidity, the answer is clear.

Therefore, other things being equal, it is the system giving the greater stiffness which we must prefer, and in this respect we altogether adopt the conclusions laid down by Mr. Cuënot in his work *Étude sur les déformations des voies de chemins de fer et les moyens d'y remédier* ([2]) : short, stiff sleepers, heavy rails, supported joints, etc.; but we add : *fastenings which cannot work loose, and cohesion of sleeper and ballast,* so as to obtain maximum stiffness.

It is also necessary to define what is meant by maximum stiffness, and to know why the smoothest running is obtained on the stiffest track.

What we actually know is, that on a new track the running is materially smoother on the first day of running than on the second (leaving settlement of ballast out of consideration).

([1]) See the investigations of Henry, Weber, Brière, Ast.

([2]) A review of Mr. Cuënot's work appeared in the *Bulletin of the Railway Congress,* No. 8, August 1906, p. 1344.

We also know that the stiffest tracks have the heaviest rails.

But a track is new only one day, and it is impossible to go on increasing the weight of rails indefinitely.

Fortunately for our finances, a track may remain new as far as rolling loads are concerned, and its weight may be increased otherwise than as regards its rails; all that is required for this purpose is to keep the fastenings as tight as they were the first day, and at the same time to add to the weight of the rails the weight of the sleepers and part of the weight of the ballast.

But in order to obtain this very simple result, it is not enough to pretend to make the flange of the rail press against the sleeper; it is necessary to make it do so in reality. That is all.

To make a fastening tight is not merely a matter of form; it is necessary to produce a pressure of so many kilograms and keep up that pressure by means of material possessing a known strength. Now neither the screw, nor still less the spike, enable a given definite pressure to be produced and maintained (1).

The point we must insist on, for it is the real cause of the evil, is that up to the present tightening has been a pretence, but never an actuality. And this is a fact which everybody knows, and nobody will contradict it.

Up to the present, people have remained satisfied with a partial stiffness, that of the rail, and it is for that reason that this has always been made heavier and heavier. Up to the present, movements, deformations due to a want of adhesion between the flanges of rails and their sleepers, have been put up with, for the sole and simple reason that it was thought impossible to prevent them.

We ourselves mean by the stiffness of a track its ability to transmit to the ground, without impact or noise, the elastic movements produced by moving rolling stock. We would say that the greatest stiffness is obtained when the deformation of the track is a minimum, for every action involves other actions, for every deformation, there are other corresponding deformations; and as in everything that lives and moves, from the original creation spring all reproduction and multiplication. Therefore, let us see that no other movements exist in our track except those absolutely necessary, and still further, let us try to reduce the latter to a minimum.

We have tried to attain these objects :

1° By using as fastenings wedges and cramps to ensure adhesion between flange and sleeper;

2° By the use of shock-absorber or deadener blocks vertically below the rails, reducing the amplitude of the elastic movements of the rails.

These are two new developments the reasons for which we will give further on.

To sum up : what we have tried to find to suit high speeds is the very smooth

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(1) See the previously quoted paper by the author on « The working loose of screws when used as rail-fastenings ».

Figs. 1 to 5. — *S tracks (for high speeds) with wedges, cramps and deadener blocks (elimination of the screw).*

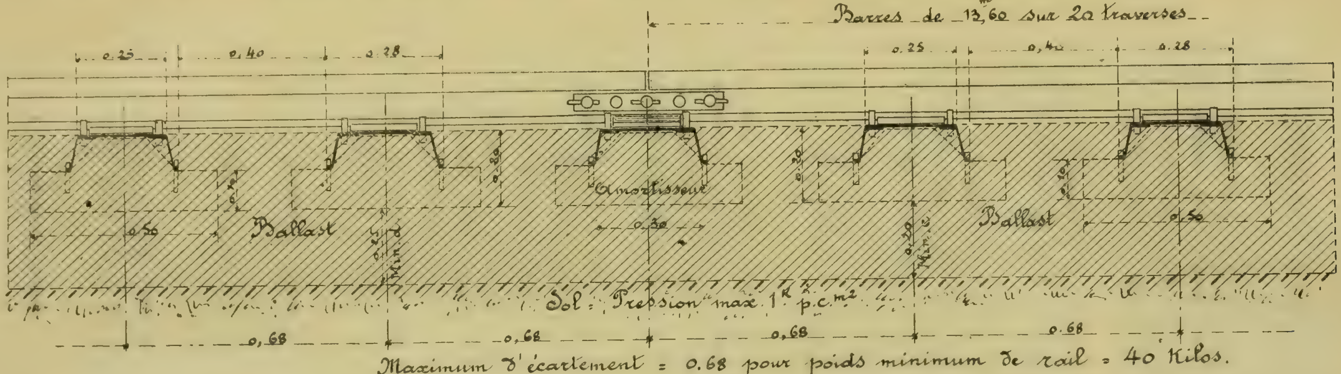
Barres de 13,60 sur 20 traverses
0.25
0,40
0.28
0.25
0,40
0.28
Amortisseur
0.30
Ballast
0.50
Ballast
0.50
Sol : Pression max. 1k p.c.m²
0,68
0,68
0,68
0.68
Maximum d'écartement = 0.68 pour poids minimum de rail = 40 Kilos.

Fig. 1. — Longitudinal section, axis of line.

Explanation of French terms : Barres de 13m60 sur 20 traverses = Rails 13·6 metres (44 ft. 7 in.) long on 20 sleepers. — Ballast = Ballast. — Amortisseur = Deadener block. — Sol. Pression max. 1 k. p. cm.². = Ground. Maximum pressure 1 kilogram per square centimetre (14·22 lb. per square inch). — Maximum d'écartement = 0 68 pour poids minimum de rail = 40 kilos. = Maximum spacing = 68 centimetres (2 ft. 2 25/32 in.) with rails weighing at least 40 kilograms per metre (80·63 lb. per yard).

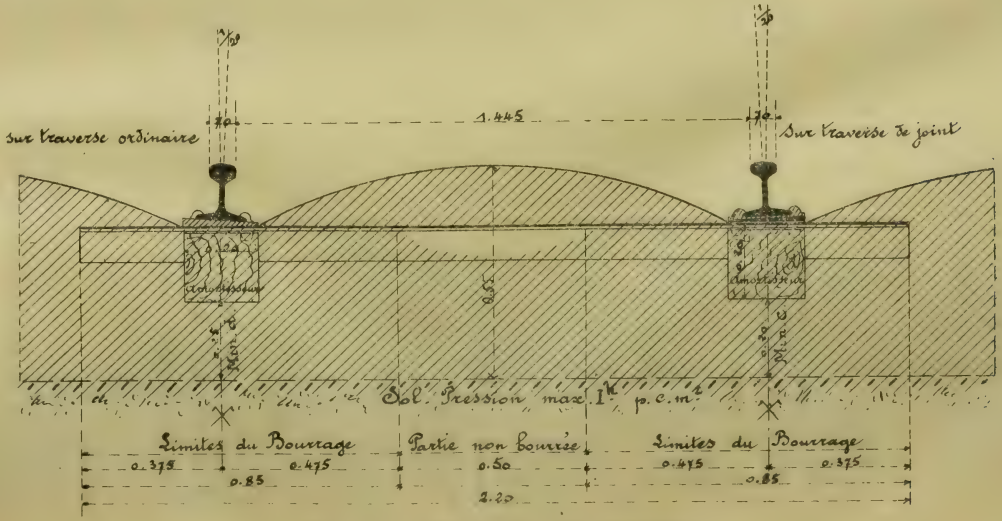

Fig. 2. — Cross-section, axis of sleeper.

Explanation of French terms : Sur traverse ordinaire = On ordinary sleeper. — Sur traverse de joint = On joint sleeper, Limites du bourrage = Limits of packing, — Partie non bourrée = Part not packed.

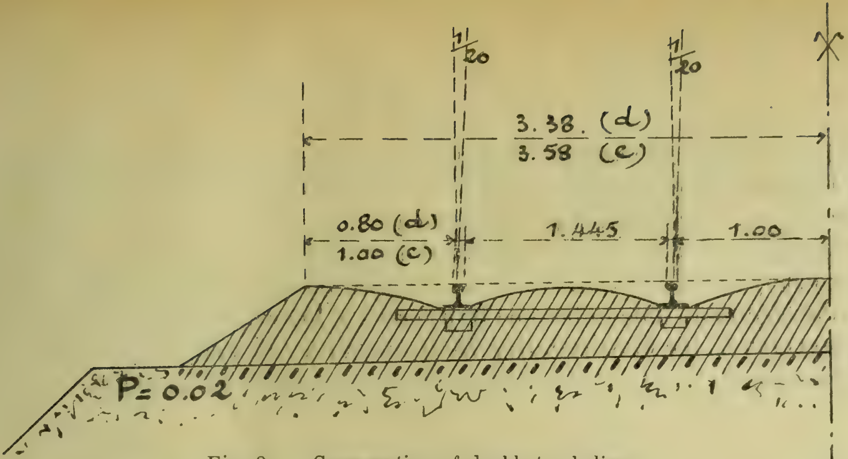

Fig. 3. — Cross-section of double-track line.

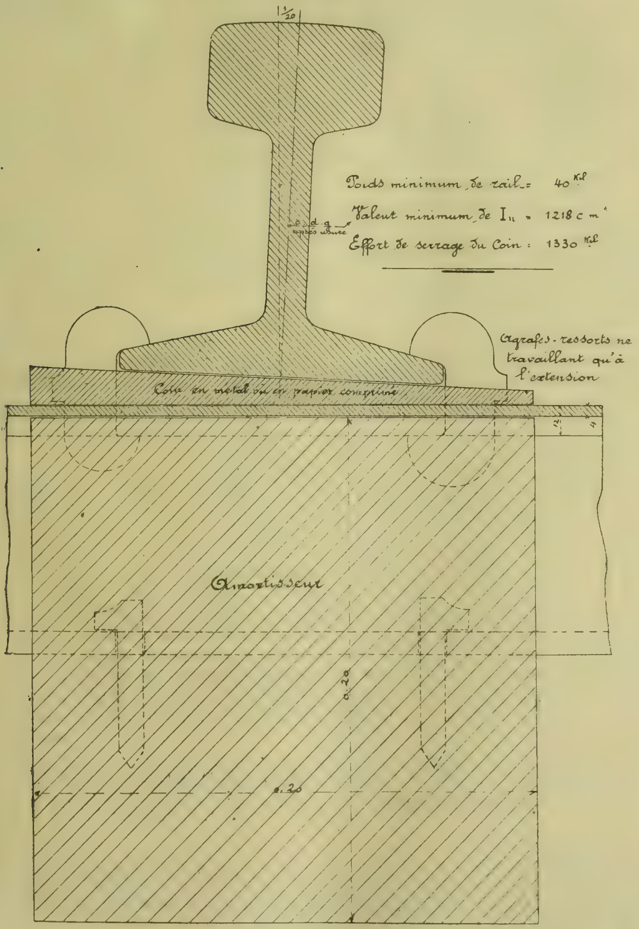
1/20
Poids minimum de rail = 40 Kil
Valeur minimum de In = 1218 cm⁴
Effort de serrage du Coin : 1330 Kil
après usure
Agrafes-ressorts ne travaillant qu'à l'extension
Coin en métal ou en papier comprimé
Amortisseur
0.20
0.20

Fig. 4. — Proper fastening capable of resisting wheel-loads of 14 tons (30,865 lb.).

Explanation of French terms : Coin en métal ou en papier comprimé = Wedge of metal or compressed paper. — Amortisseur = Deadener block. — Agrafes-ressorts ne travaillant qu'à l'extension = Spring cramps only working in tension. — Après usure = When worn down. — Poids minimum de rail = 40 kil. = Minimum weight of rail = 40 kilograms per metre (80·63 lb. per yard). — Valeur minimum de I_n = 1218 cm^4 = Minimum moment of inertia = 1,218 square centimetres squared (29·26 square inches squared). — Effort de serrage du coin = 1,330 kil. = Pressure produced by key driven in = 1,330 kilograms (2,932 lb.).

running obtained by having a very stiff track, connected with the ballast in such a way that the sleepers always remain in contact with the ballast, even at the moment when there are forces tending to raise them.

Finally, in order to reduce the depression of the sleepers, which is at its maximum immediately below the rail, we have increased the area of support there, so as to give the load more time to become transferred to the whole support, and to reduce, by absorbing it, the blow resulting from the quick and sudden transmission when there is a gap (always to be expected) between the sleeper and the ballast.

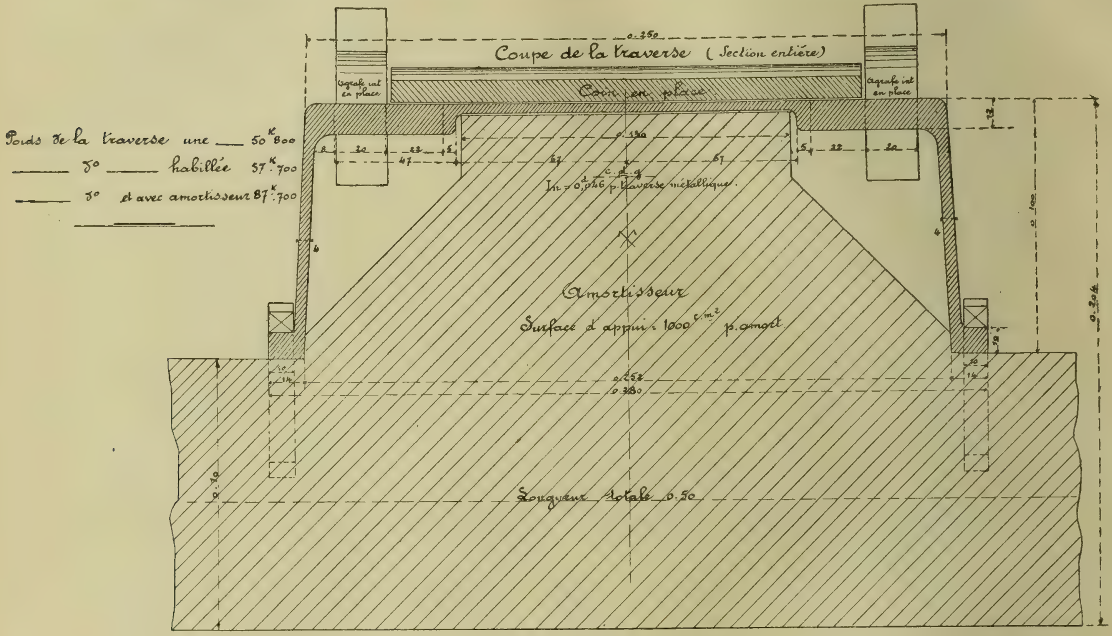
Poids de la traverse une ___ 50k800
___ d° ___ habillée 57k700
___ d° et avec amortisseur 87k700
Coupe de la traverse (Section entière)
0.250
Agrafe int en place
Agrafe int en place
Coin en place
12
0.136
8
32
22
5
47
67
67
5
22
32
c. d. g
In = 0d,046 p. traverse métallique
4
4
0.100
0.204
Amortisseur
Surface d'appui : 1000 c.m² p. amort.
12
10
14
10
14
0.254
0.280
Longueur totale 0.50

Fig. 5. — Section through sleeper.

Explanation of French terms : Poids de la traverse nue = Weight of sleeper alone. — Poids de la traverse habillée = Weight of sleeper with fastenings. — Poids de la traverse habillée avec amortisseur = Weight of sleeper with fastenings and deadener blocks. — Coupe de la traverse (section entière) = Section through sleeper (whole section). — Coin en place = Wedge in place. — Agrafe int. en place — Inside cramp in place. — *In* = 0 d. 046 p. traverse métallique = Moment of inertia referred to horizontal axis of centre of gravity of sleeper, 0·046 decimetre ($^{11}/_{64}$ inch). — Surface d'appui = 1,000 cm² p. amort. = Bearing area, 1,000 sq. centimetres (155 square inches) per deadener block. — Longueur totale 0.50 = Total length, 50 centimetres (1 ft. 7 $^{11}/_{16}$ in.).

It must not be forgotten that a reduction in the depression makes it possible to use ballast of inferior quality and results, in every case, in reducing the fatigue of the rails.

The means proposed seem to us simple : they make it possible to renew methodically a flange track having rails weighing 40 kilograms per metre (80·63 lb. per yard) and upwards by simple replacement of the sleepers.

The new compound sleeper is rolled out of mild steel, and weighs 50·7 kilograms (111·8 lb.) by itself and 57·7 kilograms (127·2 lb.) with fittings. Taking the average price of 180 francs per ton (£7.6*s.* 3·7*d.* per English ton) as basis, its cost, with deadeners, comes to 12·56 francs (10*s.* 0·57*d.*), *i. e.*, a little less than twice the cost of the present sleeper; thus, it is cheaper if we take its life into consideration.

In giving this account of our investigations, we believe we are undertaking a useful task, and meeting the wishes so frequently expressed at the different congresses when in the presence of problems not yet fully solved, and requesting all to help in their solution.

In order to facilitate the consideration of this paper, we will give *a priori* the solution proposed, giving the reasoning of the subject as and when required. (*See* figures 1 to 5.)

II. — General considerations on rail-fastenings.

As the stiffest track gives the smoothest running, all our efforts must be in the direction of obtaining the maximum rigidity which can be obtained with a rail of given weight.

Now whatever the kind and the size of the constituent parts of a track, whether they be wood or metal, that rigidity, just as in a ladder, will only be attained by the proper connecting of the side-pieces and the rungs, that is of the rails and the sleepers.

But what is a good connection?

By a good connection engineers mean a number of parts held together by a force of known amount, of such a magnitude that it exceeds the sum of the forces tending to loosen the connection, which it will subsequently be subjected to.

Such a fastening cannot work loose, if all the destructive causes tending to loosen it were allowed for when it was designed.

The destructive causes in the case of rail-fastenings have been the subject of many investigations, to which all the railways in operation have contributed; the figures we use in our calculations are taken from these investigations (1).

We also know that the vibrations to which the unloosening is attributed is really only a succession of applications and removals of pressure, produced in the rail-fastenings by the quickly moving rolling loads, the latter acting unsymmetrically on the fastenings.

But the determination of the magnitude of these destructive forces is often rather inaccurate.

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(1) In the reports to the different sessions of the Railway Congress will be found the works of Winkler, Zimmermann, Clapeyron, Couärd, Flamache and Huberti, Weber, Henry, Brière, Woehler, Michel, Howard, Ast, Loewe, Banderali, Contamin, Bauchal, Cuënot, Engerth, Post, Klemming, Bricka, Considère, Mackenzie, etc., etc.

In designing a rail-fastening therefore, we have to make a calculation based on factors which are not accurately known.

Now if we have to connect two parts of a metal frame together, the calculation of the fastening required is a very simple matter : we merely have to determine how many rivets will give enough strength to resist any forces which may act on the fastening.

Why should we not proceed in the same way when it is a question of fastening rails and sleepers together? Why use this method when designing a rail-joint (the usual practice) and not when designing other not less important parts of the track?

The method used when putting together a metal framing is thus clearly applicable to rail-fastenings, the only difference being that, in the latter case, it should be possible to take the joint apart whereas in the former that need not be the case.

These considerations may in the case of railway tracks be simply enunciated as follows :

Every fastening must be considered as a spring compressed by another spring ; it is sufficiently tight when the sum of the destructive actions is smaller than the adhesion produced by the compression of the parts.

Unfortunately this very definite compression required, if by chance it has been produced by a dog spike or a little more often by a screwspike, is never maintained by either.

Some companies, for instance the French Eastern, have recognized the necessity of producing this compression ; but given the impossibility of obtaining it by means of a screwspike (although it seems so simple to drive it in by turning it), they use special poplar slabs compressed under powerful pressure; these slabs in springing back to size, produce between the sleeper and the rail a tightness which it seems is sufficient but does not last very long.

We may perhaps be allowed to draw attention to the curious fact, that in order to correct the evil effects of a bad appliance like a screw, a device is used which, though it preserves that screw, makes it necessary to take the track to pieces at least once a year.

Evidently this proceeding is a troublesome one; it would perhaps be justified by the necessity of frequently overhauling the track. But it would be much more logical to recognize the inferiority of the screw and investigate what could be satisfactorily used to replace it.

To sum up, reasoning, calculation, observation, agree in showing that the true stiffness of a track does not depend only on increasing the weight of the constituent parts, but also on their proper adhesion which forms an economic increase of that weight.

Now this adhesion between the rail flange and the sleeper, is either entirely absent in the present fastenings, or only obtained temporarily and at too great a cost.

Having given our opinions as to the stiffness of tracks, we will now consider what stiffness is required so that the track may give smooth running at the highest speeds.

III. — Capacity-limit of the proposed track.

The capacity limit of a track appears to us to be the maximum dynamic forces that track can resist, when properly maintained; for the limits of the stresses to which the constituent parts can be subjected correspond with those forces.

The capacity can be utilized either in the way of loads or of speeds; but as the dynamic forces are the result of the movement, it would appear an advantage to know their maximum value in terms of a *static load* and a *given speed*.

Now, at present at least, the effect of the speeds concerned on the magnitude of the dynamic forces which are known by their effects, have not yet been determined by accurate and checked observations, but only the effect of the static loads.

On the other hand, the ordinary maintenance of track does not give us any information on this special point, as conditions and prices of the different items are so variable; all that we can say is that the average cost of maintenance of roads with metal sleepers is lower than that of roads with wooden sleepers, at least in all cases where the working can at all be compared.

It thus follows from what precedes that the capacity limit of a track for high speeds must be deduced from a maximum static load carried on metal sleepers; that is our course of action.

In support of this deduction, we may add that it is impossible for us to deduce the speeds which will be attained in ordinary practice from those which have already been attained; we must not confound the speeds obtained with special rolling stock, as on the Zossen-Marienfelde line (210 kilometres [130·5 miles] per hour over a short distance) (1), with speeds obtainable in practice with remunerative traffic.

If such speeds are ever used, they will only be so in the case of special traffic, of a much higher class than the average traffic; thus this will be a special case, whereas what we are seeking is the solution of a general problem which arises in current practice.

What we actually know is that at the present speeds, the heaviest rolling stock P gives (according to the quality of the track and of the rolling stock) dynamic forces equal to 1·2P on the stiffest tracks laid with rails weighing 52 kilograms per metre (104·83 lb. per yard), whereas these dynamic forces amount to 2·4P (*i. e.* twice as much) on less stiff tracks laid with rails weighing 38 kilograms per metre (76·60 lb. per yard); both tracks being well looked after and properly maintained.

We therefore can say that in the former case (52 kilograms [104·83 lb. per yard]), in which a static wheel-load of 7 tons (15,432 lb.) produces a fibre-stress of 9 kilograms per square millimetre (12,800 lb. per square inch), the limit of speed is not reached; as the resulting dynamic forces of 1·2P only produce as maximum a stress of $9 \times 1{\cdot}2 = 10{\cdot}8$ kilograms per square millimetre (15,360 lb. per square inch). Now a permanent set is only produced in such metal, of the ordinary quality, by stresses of 40 kilograms per square millimetre (56,890 lb. per square inch) and upwards.

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(1) See *Génie civil,* vol. XLII, Nos. 11 and 12, and vol. XLIV, No. 2, p. 29.

On the other hand, in the second case (38 kilograms [76·60 lb. per yard]) the same load of 7 tons (15,432 lb.) produces a fibre-stress of 14 kilograms per square millimetre (19,912 lb. per square inch); we therefore can assert that this is very near the limit, as the resulting dynamic forces of 2·4P produce a maximum stress of $14 \times 2{\cdot}4 = 34$ kilograms per square millimetre (48,358 lb. per square inch). Now a permanent set is already produced in this metal by stresses of rather less than 40 kilograms per square millimetre (56,890 lb. per square inch).

The problem of the capacity limit can be enunciated as follows :

To determine the conditions of resistance of a very stiff track, in which dynamic forces of 2·4P will not give maximum fibre-stresses exceeding 40 kilograms per square millimetre (56,890 lb. per square inch); or in other words, on 52 kilogram (104·83 lb. per yard) tracks the fibre-stresses produced by the static load must not exceed $\frac{40}{2{\cdot}4} = 17$ kilograms per square millimetre (24,179 lb. per square inch).

The wheel-load corresponding to such a stress is greater than 14 tons (30,865 lb.).

We will therefore determine, by methods similar to those ordinarily employed, the particulars of a track capable of supporting static wheel-loads of 14 tons (30,865 lb.). Such a track with fastenings strong enough for the maximum dynamic forces and having a greater cohesion with the ballast than now obtained, must be able to resist dynamic forces of $2{\cdot}4 \times 14 = 33{\cdot}6$ tons (74,075 lb.); but it must not be concluded from this that the present speeds, assumed as equal to 100 kilometres (62·1 miles) per hour, can be increased to $\frac{14 \times 100}{7} = 200$ kilometres (124·2 miles) per hour. For it is probable that the dynamic forces will increase at a quicker rate than the loads, inasmuch as generally speaking the effects of speed vary as the square of the speed itself.

It is therefore not our intention to determine a more or less doubtful figure for the speed limit, but to obtain smooth running with the *present loads at their highest speeds.*

IV. — Determination of the destructive forces possible in the case of the assumed capacity.

The rolling loads produce, in the lines over which they run, stresses in all directions. But in order to classify them they are referred to three perpendicular directions :

1° Vertical forces (depression and lifting);

2° Horizontal forces, transverse (canting and lateral displacement);
3° Horizontal forces, longitudinal (creeping).

All these forces are determined as a function of the static load producing them. We must consider these destructive forces not only from the point of view of the resistance offered to them by the constituent parts of the track, but also from that of their reciprocal actions of application and removal of compression, and of sliding; these affect more especially fastenings whose tightness ensures greater stiffness in the track.

a) VERTICAL FORCES.

The destructive vertical forces act on the rail, the sleeper and the ballast; these three members must therefore be able to support, within their limits of elasticity, the assumed static wheel-load of 14,000 kilograms (30,865 lb.), when that load is in the *most unfavourable position.*

Under such conditions, if we put a for the distance in centimetres between the sleepers (measured from centre to centre), G for the static wheel-load, namely 14 tons (30,865 lb.), and γ for a coefficient for the elastic reaction of the ballast (a variable coefficient; we take 2, the average of main line tracks), then Zimmermann's formulæ (¹) give the following results :

Maximum moment between two sleepers (most unfavourable case) . . . . $M = \frac{23}{72} Ga =$ 4,470a kilograms per centimetre (63,576 lb. per inch).

Load of rail immediately above sleeper (most unfavourable case) . . . . $P = \frac{9}{17} G =$ 7,400 kilograms (16,314 lb.).

The dynamic forces, or rather the total forces resulting from this load can thus amount to :

$2{\cdot}4P$ = 17,760 kilograms (39,154 lb.) as a maximum;
$0{\cdot}25P$ = 1,850 kilograms (4,079 lb.) as a minimum.

These dynamic forces are absorbed by the elasticity of the ballast, but if by their pressure, they increase the adhesion of the fastenings while they are growing, that is not the case while they are decreasing, and when at their minimum of 1,850 kilograms (4,079 lb.) the fastening is correspondingly unloaded, it can be affected by a horizontal force tending to make the flange slide on the sleeper, if that horizontal force is greater than the friction produced by the vertical pressure of 1,850 kilograms (4,079 lb.).

In such a case, a horizontal force of 1,850 × 0·4 = 740 kilograms (1,631 lb.) would suffice, in the case of two parallel metal faces, unlubricated, to produce a displacement of the rail relatively to the sleeper. This case is, however, not the

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(¹) *Vide* Mr. Zimmermann's treatise.

most unfavourable one; the latter occurs when there is no vertical force apart from the weight of the rail, when the track is not loaded. In such a case, the track is subject much more to deformation than when heavy loads are running over it, *because the absence of adhesion* between the flange and the sleeper then makes deformation possible by loads acting at a distance.

Now, just as to every action there is a reaction, every deformation produces other deformations and it is the sum total of these deformations which, in our opinion, are the most destructive agent acting on tracks.

Whether a loaded rail is subjected to a stress of 1 or of 12 kilograms per square millimetre (of 1,422 or of 17,067 lb. per square inch) is not of itself of importance, as long as such stress is well within the elastic limit; the important factor is the amount of movement and of bending which results from that elasticity, movements which produce shock and friction, even at some distance off, that is to say, useless work which only results in heat and wear and tear.

It is hence absolutely necessary to prevent these movements by pressing the two pieces in contact together, by giving them an initial adhesion which is stronger than the destructive forces mentioned above.

The adhesion of the fastening must thus be designed for the maximum transverse forces less the minimum vertical load.

And when the rail is lifted, as when the rolling load approaches, the vertical load becomes nil; the adhesion or compression initially given must therefore correspond to the maximum amount of the transverse forces which will be determined subsequently.

b) TRANSVERSE FORCES.

The transverse forces experimentally measured or calculated from the deformations produced, vary (after deduction of the friction between tires and rails) between 0·25G and 0·38G, G being the static load originating them. In our case, therefore, the maximum transverse forces will be :

$$0{\cdot}38 \times 14{,}000 \text{ kilograms} = 5{,}320 \text{ kilograms } (11{,}729 \text{ lb.})\ (^1).$$

But the peculiarity of the transverse forces is that they are at a maximum not when the vertical loads are greatest, but on the contrary with unloaded axles, as the vertical loads increase the adhesion of the rail to its supports.

Now the experiments which give us information on this point are very numerous, and refer very largely to the breaking of the connection between the sleepers and the ballast.

As these values can only be obtained on the assumption of an at least equal transverse force acting on the rail, we can at least use them for checking the figure determined above.

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(1) See the investigations of Winkler, Weber, Brière, Couärd, Woehler.

The most unfavourable experiments obtained on an unloaded track ballasted in the usual way (French Eastern and French Northern) showed that the connection between the sleepers and the ballast was broken when a force of 8,000 kilograms (17,637 lb.) acted; the track consisted of rails 11 and 12 metres (36 ft. 1 in. and 39 ft. 4 in.) long laid on fourteen and sixteen sleepers respectively.

If we assume with Wöhler that the maximum transverse force between the flange of the rail and the sleeper is equal to $\frac{37}{67}$ of the total horizontal force, we obtain the value of $\frac{37}{67} \times 8,000 = 4,400$ kilograms (9,700 lb.) in this case, whereas in the other we had 5,320 kilograms (11,729 lb.).

It is our duty to take the higher value; the maximum transverse force as between the flange and sleeper, the force tending to spread the track, will therefore be taken as equal to 5,320 kilograms (11,729 lb.).

It is evident that on a stiff track, the force tending to produce lateral displacement will be smaller per sleeper, as a larger number of sleepers will be acted on at once; but how is it distributed and what maximum must we assume as acting on one sleeper?

As on an unloaded track a force tending to produce lateral displacement can only be produced by the approach of the rolling load, it is evident that the sleepers further off will be subjected to a smaller force than those which are nearer the load; on the other hand, when such a force is produced by the sideway oscillation of unloaded axles, all the sleepers under an empty wagon will be affected, and as there cannot be less than four of them, we think we may deduce that the maximum transverse force will be distributed as a minimum over four sleepers; this gives as result $\frac{5,320}{4} = 1,330$ kilograms (2,932 lb.).

That being so, the vertical force our fastening must be able to resist being according to Winkler $0{\cdot}48\ G = 0{\cdot}48 \times 14,000 = 6,720$ kilograms (14,815 lb.), we obtain per fastening of rail flange to sleeper:

1° Vertical force, canting . . . . $\frac{6,720}{4} =$ 1,680 kilograms (3,704 lb.), acting on the fastenings.

2° Transverse force, sliding. . . $\frac{5,320}{4} =$ 1,330 kilograms (2,932 lb.), to be produced by driving in the wedges.

These two values are confirmed by being nearly in the ratio of $\frac{33}{26}$ given by Winkler for a rail having a width of base equal to its height.

It must not be forgotten that as the transverse forces are produced by the rolling stock, a considerable fraction of the destructive forces as determined above can be reduced by suitable construction of the rolling stock, especially of the locomotives.

c) LONGITUDINAL FORCES. — CREEPING.

The longitudinal forces acting on tracks are very great (¹), but the determination of their amount has hitherto been very uncertain; it is a very complicated question.

The remedies for reducing these destructive forces are to be found more especially in suitable construction of the rolling stock; at least that is the generally accepted opinion.

As regards the track, even if it is impossible to deduce an exact formula for these forces from conclusive observations, it may yet be admitted that one of the important causes is the impact of the wheel when passing from the trailing rail end to the facing rail end, when the elastic non-supported joints with fishing having little strength transversely, only transmit part of the transverse force acting on the trailing rail end to the facing rail end.

In such a case, a supported joint and more especially a greater transverse strength would materially reduce creeping, by giving the track more continuity. This is what we have attempted to obtain.

But the chief factor of the longitudinal forces is the movement of the masses; now as dynamic forces increase very rapidly with the speed, it cannot be denied that their absorption, in cases of braking, are one of the chief factors in creeping, when such braking tends to substitute friction of sliding for the normal friction of rolling.

We have only two factors to counteract this destructive action: the weight of the track and the resistance of the ballast. It therefore appears to us that the logical deduction is that the best results will be achieved by the *best combination of these two factors*, and that here also the proper adhesion of the fastenings will produce a maximum resistance not hitherto attained.

We do not leave out of consideration, that according to certain observations, the resistance of the friction between the sleepers and the ballast has by itself not sufficed to prevent creeping, but we have every reason to believe that consideration was only paid in those observations to the adhesion produced naturally between the flange and the loaded sleepers, and not to the fact that the unloaded track, whether in front or even behind the load, allowed (owing to insufficient pressure of the screwspikes on the flange) the rails to slip on the sleepers, by letting the rails so compressed endways bend transversely, thus reducing their resistance to creeping.

In such a case, it can be readily understood that as only the loaded sleepers were affected by the ballast, the resistance so localized might not suffice even if the screwspikes had been tightened recently.

A greater stiffness of track obtained by properly tight fastenings would, therefore, have as result that not only would the ballast below the loaded sleepers be affected,

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(¹) See the investigations of Couärd, Engerth, Zimmermann and Ast.

but also that below the non-loaded sleepers acted on by the tension of the rails behind the load and the compression of those in front of it, more especially if we try to obtain as much cohesion as possible between the track and the ballast.

As we therefore do not know all the factors involved, it is impossible for us to determine in advance the amount of compression we must have in the fastenings in order to resist creeping, and we will assume that fastenings designed to resist the vertical and transverse forces will also resist the longitudinal forces; we are however unable to prove this.

In such a case, experience is the sole guide.

Let him who has never offended throw the first stone or give us the data which we could utilize.

We will give as summary of this chapter the following table, showing the destructive actions which are produced by the assumed static wheel-loads of 14,000 kilograms (30,865 lb.) and which our track has to resist.

1° Maximum moment between two sleepers (most unfavourable case)		M = 4,470 kilograms per centimetre (63,576 lb. per inch).
2° Load on rail immediately above sleeper (most unfavourable case)		P = 7,400 kilograms (16,314 lb.).
3° Total vertical forces produced by moving loads	maximum	17,760 kilograms (39,154 lb.).
	minimum	1,850 — (4,079 lb.).
4° Vertical force, canting (fastenings) (per fastening) . .		1,680 — (3,704 lb.).
5° Transverse force, sliding (per fastening)		1,330 — (2,932 lb.).
6° Longitudinal force, creeping (per fastening)		Assumed.

With the help of these figures we will determine, in the next chapter, the strength required by each of the constituent parts of our track.

V. — Constitution, shape and strength of the constituent parts of the track.

a) BALLAST.

It is understood that the quality of the ballast is of paramont importance, more especially when it is, as in this investigation, a question of extending the field of action of the dynamic forces; but as on the other hand the question is not the construction of new lines, but the systematic renewal of lines now in operation, the selection of the ballast cannot be a factor in our calculations, as the ballast is already there. We can only assume that ballast of average quality is used.

We therefore assume an average state of affairs, practically corresponding to $\gamma = \frac{B}{D} = 2$ in Zimmermann's formulæ; this represents the average conditions now existing on the trunk lines.

Moreover, we will lay down the condition that the vertical loads are so distributed that the maximum pressure on the ballast at any point does not exceed 3 kilograms per square centimetre (42·67 lb. per square inch) of supporting surface.

Distribution of the vertical forces.

But how are we to distribute these forces in the short sleeper we are taking?

Theoretically, our sleeper should become uniformly depressed at every point; practically, we know that the depression is nearly always greater immediately below the rail.

We have solved this ticklish question by increasing : 1° the supporting surface immediately below the rail; 2° the stiffness of the sleeper.

At this point, and over a width of 20 centimetres (7 $^7/_8$ inches) under each of the flanges, we have increased the supporting surface of the sleeper, which was only 28 × 20 = 560 square centimetres (86·80 square inches), to 50 × 20 = 1,000 square centimetres (155 square inches), the latter being the size of the deadener blocks, the function of which will be considered later on.

The results obtained by Mr. Cuënot with the short H. Michel sleeper have led him to recommend uniform packing extending 35 centimetres (1 ft. 1 $^3/_4$ in.) to the right and to the left of the point where the loaded rail acts on the sleeper. Will this arrangement, which seems to have given good results with the present speeds, suffice for higher speeds and greater dynamic forces?

That will depend on the quality of the ballast used. In fact, as the supporting surface of the new H. Michel sleeper is only 25 × 70 = 1,750 square centimetres (271·26 square inches), the total practical pressure with ordinary ballast would be 1,750 × 3 = 5,250 kilograms (11,574 lb.), corresponding to a static wheel-load of say 10 tons (22,046 lb.); unless indeed we assume such large depressions of the supports that the advantage of the shape would be entirely lost, or unless ballast of better quality were to be used everywhere.

As we have assumed the ballast to be of ordinary quality, we are compelled to increase the supporting surface so as to correspond to the greater speeds.

But then another consideration arises, for the width of the sleepers cannot exceed certain limits, which are all the more reduced in our case so as to enable us to have the sleepers as close together as possible.

Now if putting *a* for the distance between sleepers, centre to centre, and *l* for the width of the sleepers, as the clear space between sleepers must not be less than 40 centimetres (1 ft. 3 $^3/_4$ in.), so as to allow for easy packing, it follows that we have

$$0{\cdot}40 = a - 2\,\frac{l}{2} = a - l$$

and that two wide sleepers would have to be too far apart.

Hence we have limited the width of our sleeper to 28 centimetres (11 inches); but then if only 70 centimetres (2 ft. 3 $^9/_{16}$ in.) of length are packed, our rail-load of 7,400 kilograms (16,314 lb.) gives a compression of :

$$\frac{7{,}400}{28 \times 70} = 3{\cdot}7 \text{ kilograms per square centimetre (52·62 lb. per square inch).}$$

which is greater than possible when the ordinary ballast we assume is used.

It is in the deadener block that we have found the extra supporting surface we were in want of, and as it seemed to us prudent to assume that the short sleeper would not always behave as we would theoretically desire, we have adopted, inside the track, an extra amount of packing not only capable of making up the supporting surface we were lacking, but also the generally higher depression at the middle than at the ends, and so getting a better chance of equal depression at all points.

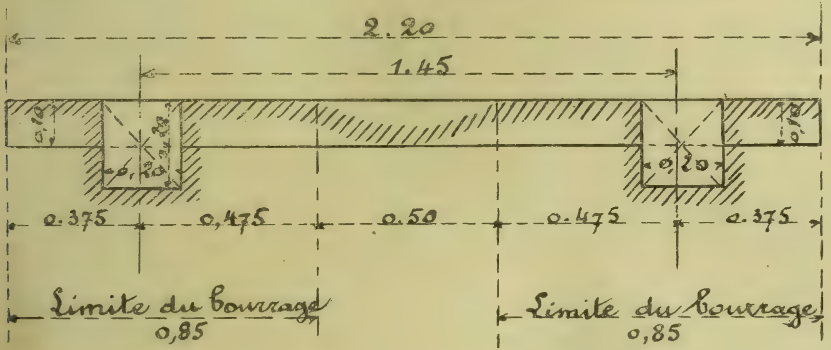

Fig. 6. — Arrangement of packing.

Bearing area	of deadener blocks : 2 (0·5 × 0·2) . . . . . =	2,000 square centimetres	(310·01 square inches).
	of sleeper : 2 (0·85 × 0·28) . . . . =	4,760 — —	(737·83 — —)
	Total. . .	6,760 square centimetres	(1,047·84 square inches).
Less : 2 (0·20 × 0·28) of the deadener blocks	. . . . =	1,120 — —	(173·61 — —)
	Net bearing area. . .	5,640 square centimetres	(874·23 square inches).

Explanation of French terms : Limite du bourrage = Limits of packing.

Under these conditions, our sleeper which is 2·2 metres (7 ft. 2 $^5/_8$ in.) long will be packed as shown in figure 6; the pressure, per square centimetre of supporting surface, will be :

$$\frac{14,800}{5,640} = 2{\cdot}6 \text{ kilograms (36·98 lb. per square inch) approximately;}$$

and under the greatest dynamic loads (say 17,760 kilograms [39,154 lb.] per wheel), the pressure will be

$$\frac{17,760}{2,820} = 6{\cdot}2 \text{ kilograms per square centimetre (88·18 lb. per square inch);}$$

whereas the dimensions of the H. Michel sleeper are such, that under similar conditions the pressure would be

$$\frac{17,760}{1,750} = 10{\cdot}1 \text{ kilograms per square centimetre (143·65 lb. per square inch),}$$

that is to say that if the same ballast were used, it would be very much more compressed or crushed.

Distribution of the transverse forces.

As regards lateral displacement, the resistance of the ballast is of great importance, particularly when metal sleepers are used.

The condition of the surfaces is here a great factor, and as we require great cohesion with the ballast, we must by some special means obtain the extra adhesion which metal surfaces do not of themselves afford.

We have found that per sleeper the maximum transverse force is 1,330 kilograms (2,932 lb.); now in order to resist this force we have:

1° The surfaces of the deadener blocks (wood);
2° The metal surfaces.

If we assume that with a wooden sleeper measuring 270 × 20 × 15 centimetres (8 ft. 10 $^{5}/_{16}$ in. × 7 $^{7}/_{8}$ × 5 $^{15}/_{16}$ inches) the force required to break its connection with the ballast is $\frac{8,000}{4} = 2,000$ kilograms (4,409 lb.), we can, for the different surfaces, take a coefficient of cohesion of 3 for the horizontal surfaces, 2 for the vertical surfaces, and for the transverse surfaces three times the weight of the ballast which has to be displaced.

The 270 × 20 = 5,400 square centimetres (837·03 square inches) of horizontal surface will give 3 × 5,400 = 16,200; 270 × 15 × 2 = 8,100 square centimetres (1,255·55 square inches) of vertical surface will give 2 × 8,100 = 16,200; together 32,400.

The 20 × 15 = 300 square centimetres (46·50 square inches) of transverse surface will give 0·03 × (1·03 — 0·445) × 1,500 × 3 = 80 kilograms (176·4 lb.).

That is, for the horizontal faces:

$$\frac{(2,000 - 80) \times 16,200}{32,400 \times 5,400} = 0\cdot 2 \text{ kilogram per sq. centimetre (2·84 lb. per sq. inch) approximately;}$$

and for the vertical faces:

$$\frac{(2,000 - 80) \times 16,200}{32,400 \times 8,100} = 0\cdot 1 \text{ kilogram per sq. centimetre (1·42 lb. per sq. inch) approximately;}$$

Using the same method in the case of the compound metal sleeper, we have:

Deadeners:

Two transverse faces (normal pressures)	1,550 square centimetres (240·26 square inches) $3 \times 1,550 \times \frac{10\cdot 3 + 14\cdot 5}{2} \times 1\cdot 500 = 864$ kilograms (1,905 lb.).
Horizontal faces (by friction) .	2 × 50 × 20 + 4 × 20 × 10 = 2,800 square centimetres (434·02 square inches) at 0·2 kilogram per square centimetre (2·84 lb. per square inch) = 560 kilograms (1,235 lb.).
Vertical faces (by friction) . .	4 × 20 × 10 = 800 square centimetres (124 square inches) at 0·1 kilogram per square centimetre (1·42 lb. per square inch) = 80 kilograms (176·4 lb.).

Metal surfaces not taken into consideration.

This gives a total of 1,504 kilograms (3,316 lb.), that is to say that the wood surfaces of the deadeners would by themselves be able to resist the 1,330 kilograms (2,932 lb.) of force tending to produce lateral displacement, and that it is not necessary to consider the metal surfaces.

It will however be observed that their shape and dimensions are such that they adhere considerably to the ballast, even affecting the ballast under the sleeper, which between the rails is quite encased.

Distribution of the lifting forces.

In the case of wooden sleepers, if we assume three times the weight of the sleeper, say 240 kilograms (529 lb.), we obtain a resistance to lifting of

$$\frac{240}{270 \times 15 \times 2} = 0{\cdot}03$$ kilogram per sq. centimetre (0·427 lb. per sq. inch) of vertical surface.

With the metal sleeper we will have :

1° Weight of sleeper with deadeners		= 88 kilograms	(194·0 lb.).
2° Vertical surfaces	775 × 4 × 0·03	= 93 —	(205·0 lb.).
	200 × 4 × 0·03	= 24 —	(52·9 lb.).
3° Weight of ballast to be lifted		= 50 —	(110·2 lb.).
4° Amount due to metal surfaces, loaded or not, not considered.			
Total.		255 kilograms	(562·1 lb.).

So that altogether all the resistance which a long wooden sleeper can give, can not only be obtained with the short sleeper with deadeners, but even greater ones.

The connection with the ballast is ensured by the fact that instead of the blows formerly given by the flange to the sleeper, we now have an initial adhesion, transmitting directly to the ballast the forces acting on the rail, without other than purely elastic movements in the track, which leave no trace as long as the elastic limit of the supporting medium is not exceeded.

Now this is a point of great practical importance; even ballast of medium quality will suffice for the new speeds, when we use this short sleeper in our track.

Normal profile of the line.

Any existing main line profile is very suitable as our sleeper is shorter and we only exceed the depth of the seat of a wooden sleeper very little.

Actually, however, with short sleepers it will generally be possible to reduce the width of the formation level; more especially will our sleeper, by the resistance to lateral displacement being below the rails, make this reduction still more noticeable. Its economic importance will not be overlooked by engineers who are constructing new lines. In either case, part of the present ballast becomes available, which we would use to cover the road, the fastenings being left exposed so as to facilitate their maintenance.

b) SLEEPERS.

We have chosen metal sleepers for the following general reasons :

1° They have a longer life;

2° They require less maintenance.

The particular reasons against their general use are :

a) The difficulty in fixing the fastenings;

b) The complex form required so that the rail may have the requisite inclination;

c) The small adhesion to the ballast;

d) The sonorousness resulting when metal is in contact with metal and there is an absence of adhesion.

We have tried to find a simple remedy for each of these defects, but if our remedies should prove inferior to those which will be found ultimately, the fundamental reason, that which has guided us and should guide all subsequent investigators, should be the *possibility of obtaining the best fastening by the simplest means*.

What is required is this :

1° To maintain the original stiffness of the track;

2° To make the track one completed whole, well fixed in the ballast.

We have adopted a plain rolled sleeper :

1° For reasons of economy;

2° In order to avoid any initial strains.

Metal sleepers which have been made by complicated stamping, are like the screws, appliances which are in a bad state before they are used.

It is evident that in order to produce a permanent alteration in shape when the material is worked so to say in the cold, the elastic limit of that material must be exceeded. It is then no longer possible to reckon on that elastic limit; that sleeper or that screw can no longer resist as designed.

As shape we have selected a large channel section, with the parts most subjected to stress reinforced.

The cross-section is shown in the drawings (*see* fig. 5).

The following are the dimensions of our sleeper :

1° Length	2·20 metres	(7 ft. 2 $^{5}/_{8}$ in.).
2° Width of top	0·25 metre	(9 $^{13}/_{16}$ inches).
3° Total width of bottom	0·28 —	(11 inches).
4° — height of section.	0·10 —	(3 $^{15}/_{16}$ inches).
5° Height of deadeners	0·20 —	(7 $^{7}/_{8}$ —).

6° Area of cross-section of metal	0·296 sq. decimetre (4·59 sq. inches).
7° Weight of sleeper alone	50·8 kilograms (112 lb.).
8° — — with fastenings	57·7 — (127·2 lb.).
9° Moment of inertia referred to horizontal axis of centre of gravity.	0·046 decimetre ($^{11}/_{64}$ inch).

Under each rail a block of wood 20 centimetres ($7\ {}^{7}/_{8}$ inches) wide supports the non-reinforced part of the top of the sleeper and transmits to the ballast, at a depth of 20 centimetres ($7\ {}^{7}/_{8}$ inches), the rail-loads as soon as they are applied; that is to say to a layer of the ballast which is firmer than the upper layers.

We have called this block a *deadener;* its functions are as follows :

1° To distribute the rail-loads, as soon as produced, on to a solid layer of ballast, the deadener forming a foundation for the sleeper ;

2° To reduce the total compression of the ballast by increasing the bearing area which can easily be packed;

3° To deaden the shocks by giving the top of the sleeper more time for the whole distribution of the rail-loads ;

4° To reduce the depression and consequently enable ballast of medium quality to be used ;

5° To resist the lateral displacement and the lifting of the sleeper;

6° To increase the weight of the sleeper and the mass of the track ;

7° To reduce the sonorousness under the sleeper.

The dimensions of the deadeners are as follows (*see* the figures) :

1° Length at bottom	0·50 metre (1 ft. $7\ {}^{11}/_{16}$ in.).
2° Total thickness under sleeper	0·20 — ($7\ {}^{7}/_{8}$ inches).
3° Thickness at front and back	0·10 — ($3\ {}^{15}/_{16}$ —).
4° Width.	0·20 — ($7\ {}^{7}/_{8}$ —).
5° Weight	15 kilograms (33 lb.).

The deadener takes against the web of the sleeper and the bottom of the wings to which it adheres and which it keeps from shifting. It is fixed to the wings of the sleeper by four spikes working in shear which resist the forces tending to produce lateral displacement; so that the maximum stresses each is subjected to is $\frac{1,330}{4 \times 2} = 166$ kilograms (366 lb.).

As the spikes have a cross-section of $10 \times 10 = 100$ square millimetres (15·50 square inches), the stress is only $\frac{166}{100} = 1{\cdot}66$ kilogram per square millimetre (2,361 lb. per square inch); this explains sufficiently why this appliance, otherwise bad, is used here.

We may remark that this shearing action is rare and accidental, for the least vertical pressure substitutes friction between the wood and the metal for the shear; this friction is equivalent to $P \times 0{\cdot}65$, so that it amounts to 166 kilograms (366 lb.)

when $P \times 0{\cdot}65 = 166$ or $P = 256$ kilograms (564 lb.); in other words, as soon as the rail-load amounts to 256 kilograms (564 lb.) the deadener and sleeper will seize together and friction will act instead of shear.

Then also the wood must never be subjected to more than a given compression by the rail-load; now the bearing area of the wings on the deadeners is

$$2 \times 200 \times 14 = 5{,}600 \text{ square millimetres (868·03 square inches)},$$

a safe load being 66 kilograms per square centimetre (938·71 lb. per square inch); now

$$56 \times 66 = 3{,}696 \text{ kilograms (8,148 lb.)},$$

a load which can never be attained as at that moment the whole sleeper bears on the ballast which is only subjected to a pressure of 2·2 kilograms per square centimetre (31·29 lb. per square inch), whereas we have assumed 66 kilograms per square centimetre (938·71 lb. per square inch) in calculating the compression of the deadeners.

As regards its resistance, our sleeper section gives as moment of inertia referred to the horizontal axis through its centre of gravity

$$I_n = 0{\cdot}046 \text{ decimetre } (^{11}/_{64} \text{ inch}).$$

The axis through the centre of gravity is 73·3 millimetres (2 $^{57}/_{64}$ inches) above the lowest fibre and 26·7 millimetres (1 $^{3}/_{64}$ inch) below the highest, the total height of the metal therefore being 10 centimetres (3 $^{15}/_{16}$ inches). Consequently,

$$\frac{I}{v \text{ below}} = \frac{0{\cdot}046}{0{\cdot}733} = 0{\cdot}06275.$$

Given the arrangement of the loads, and assuming an impossible case, namely the ballast completely stripped from the sleeper which would only be supported at its ends and acted on by the maximum rail-load of 7,400 kilograms (16,314 lb.) determined *supra*, we would have in the most strained sections, *i. e.*, immediately below the rail, a resistance of

$$7{,}400 \times 0{\cdot}375 = R \left(\frac{0{\cdot}046}{0{\cdot}733} = 0{\cdot}06275\right);$$

whence

$$R = \frac{7{,}400 \times 0{\cdot}375}{0{\cdot}06275} \text{ or } 4{\cdot}4 \text{ kilograms per sq. mill. (6,258 lb. per square inch) in the solid section}$$

and

$$\frac{4{\cdot}4 \times 4}{3} = 5{\cdot}9 \text{ kilograms per square millimetre (8,391 lb. per square inch) in the reduced section.}$$

On the top, the highest fibre being 0·267 decimetre (1 $^{3}/_{64}$ inch) above the axis passing through the centre of gravity, we have for the most strained fibre

$$7{,}400 \times 0{\cdot}375 = R \left(\frac{0{\cdot}046}{0{\cdot}267} = 0{\cdot}1722\right)$$

whence

$R = \frac{7{,}400 \times 0{\cdot}375}{0{\cdot}1722}$ or 1·6 kilograms per sq. mill. (2,276 lb. per sq. inch) in the solid section,

and

$\frac{1{\cdot}6 \times 21}{11}$ 3·1 kilograms per square millimetre (4,409 lb. per square inch) in the reduced section.

c) Rails.

In order to know the weight of rail to be utilized in the renewal of tracks according to the system proposed, we must determine the minimum weight of rail capable of supporting a live load of 14,000 kilograms (30,865 lb.).

This calculation of course depends on the condition of a minimum spacing of the sleepers; now if we have a clear space of 40 centimetres (1 ft. 3 $^3/_4$ in.) to make proper packing possible, our minimum spacing will be given by :

$$a = 0{\cdot}40 + 2\,\frac{l}{2};\ l \text{ being equal to 28 centimetres (11 inches).}$$

Hence a minimum = 68 centimetres (2 ft. 2 $^{25}/_{32}$ in.).

Under these conditions, the maximum stress on the rail between two sleepers is given by Zimmermann's formula :

$$M = \frac{8\gamma + 7}{4\gamma + 10}\,\frac{Ga}{4},$$

a formula in which we take $\gamma = \frac{B}{D} = 2$ (see the reasons given under ballast),

$$G = 14{,}000 \text{ kilograms (30,865 lb.)}$$

and

$$a = 68 \text{ centimetres (2 ft. 2 } ^{25}/_{32} \text{ in.).}$$

The maximum stress will therefore be,

$$M = \frac{23}{72} \times 14{,}000 \times 68,$$

which will be the maximum resistance we can expect from rail-metal, namely 15 kilograms per square millimetre (21,334 lb. per square inch) for the static loads; this may become 15 × 2·4 = 36 kilograms per square millimetre (51,202 lb. per square inch) with the live loads.

We therefore have

$$\frac{23 \times 14{,}000 \times 68}{71 \times 1{,}500} = \frac{I}{v} = 203 \text{ cubic centimetres (12·39 cubic inches).}$$

for the weakest rail capable of resisting the loads in question.

This value of 203 cubic centimetres (12·39 cubic inches), to be applied to large rails the centre of gravity of which is about 6 centimetres ($2\ ^3/_8$ inches) above the base when fully worn out, gives

$$I = 203 \times 6 = 1{,}218 \text{ square centimetres squared (29·26 square inches squared).}$$

Now this value of I is that of rails weighing about 40 kilograms per metre (80·63 lb. per yard). Therefore, this weight should be considered the minimum for tracks on which the proposed system is to be applied; but this should first be checked, as the value of I varies not only with the weight but also with the cross-section of the rail. The cross-section assumed must be that of the rail fully worn out.

Evidently the cross-section when new will be very superior, as a 50 kilograms (100·79 lb. per yard) rail having I = 1,600 square centimetres squared (38·44 square inches squared) will give, with a static wheel-load of 14,000 kilograms (30,865 lb.) and a sleeper-spacing of 68 centimetres (2 ft. $2\ ^{25}/_{32}$ in.),

$$R = \frac{23 \times 14{,}000 \times 68 \times 6}{72 \times 1{,}600} = 1{,}140 \text{ kilograms per sq. centimetre (16,214 lb. per sq. inch);}$$

or, with the maximum dynamic effect :

$$1{,}140 \times 2{\cdot}4 = 2{,}736 \text{ kilograms per square centimetre (38,914 lb. per square inch),}$$

in a metal the elastic limit of which can be as high as 4,500 kilograms per square centimetre (64,000 lb. per square inch), given the quality and homogeneity now generally specified for rails.

The fastenings being properly designed and maintained, the rail weighing 50 kilograms per metre (100·79 lb. per yard) will therefore give, and very safely, excellently smooth running; for the elasticity of the other parts of the track is not half as much.

The proposed system of track is therefore suitable for Vignoles rails of all shapes; but in the interest of the proper equilibrium of the resisting forces, it is advisable for the flange to be as wide as possible.

VI. — Design of the fastenings.

Our fastenings consist of cramps and wedges.

The wedges produce the pressure recognized necessary.

The cramps maintain these pressures, just like a spring would within its limit of elasticity.

We have explained in our paper " On the working loose of screws when used as rail-fastenings ", which we already have quoted, why we reject the screw; we will give a summary of the reasons for those unable to refer to that paper.

The rolling loads act on the rail-heads in all directions ; the rails only transmit unsymmetrical forces to the fastenings.

Now if screws of whatever shape already are unsatisfactory when acted on by symmetrical forces (1), none of them can stand unsymmetrical forces without deterioration as soon as they are tightened up, that is to say, before they are used.

A screw, when acted on by the considerable unsymmetrical forces, such as those which act when it presses the flange of a rail on to a sleeper, becomes badly deformed ; the upper part of the threads on the side of the flange alone bear against the lower part of the threads of the nut on the same side ; this reduction in bearing area has as result that the metal of the thread is strained far more than had been intended.

This bad distribution of bearing area of thread results in permanent deformation while the screw is being turned by the spanner ; the distribution becomes worse and worse, and the power applied to the spanner, instead of being utilized in producing the pressure required, becomes the chief destructive agent acting on that screw ; the force actually utilized being only the difference between the *forces acting between the threads in all directions.*

On the other hand, if a screw really bears on a rail flange (which is rarely the case), the unsymmetrical force which it resists is reduced to nil as each rolling load passes ; at such moment, the core of the screws and the threads which bear contract on the side near the rail-flange, and extend on the other side ; the screw is straightened by the action of its elasticity, and during this movement which corresponds to the disappearance of the tensile stresses, the slipping action, which alone is present, reproduces, but inversely, the torsional movements produced by the spanner when tightening it up, so that it loosens.

In fact the screw, which is an ingenious appliance because it both produces and maintains pressure, must be rejected *because it does both badly.*

And when in a theoretically improved screw, we try to find what we can advantageously retain, we are led to give up the production of pressure in order to ensure maintaining it by what remains when the useless parts of the screw have been removed ; *this remainder is the cramp.*

Thus, in fastening together a rail and a sleeper, the principle of division of work leads to the rejection of this screw which is universally used in spite of its great defects from the railway point of view, and to its substitution by two simple appliances, the wedge for producing pressures, the cramp for maintaining them.

The screw was the development of the wedge and the cramp ; experience leads us to resolve the screw into its two constituents, the wedge and the cramp.

The combination of the two simple appliances has in this case produced a bad result, because it has resulted in an evil reduction in the areas in contact and in a defective distribution of the considerable stresses this combination, that is the screw, is subjected to, both as regards its successive threads, and its head which only gets a bearing along a generating line.

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(1) Mr. Bodin's lectures, at the *École centrale des arts et manufactures.*

The division of the screw into a wedge and a cramp will give a good result. That is certain, because it makes it possible to increase the bearing areas and to distribute the same stresses better.

It is moreover evident to any independent and unprejudiced observer, that what is good in a screw in spite of its acknowledged defects, cannot become bad when those defects are eliminated.

Seeing the absolute necessity of obtaining proper adhesion, the question of complexity cannot be raised as an objection, for the complexity is not in the number of separate pieces, but in the shape of the screw itself, which is a bad combination of two devices, the cramp and the wedge, which are excellent separately.

Moreover, we are at a period when reason controls all; it would be very surprising if it would not prevail in a case where only a desire for simplification has led to results universally recognized as unsatisfactory.

a) PRODUCTION OF PRESSURE IN OUR FASTENING.

The pressure is produced by a *thin wedge*, which forms a bed-plate or foundation-plate under the flange of the rail, distributing the vertical loads over a larger area of the sleeper than would be done by the flange itself.

This wedge, which has one of its faces only tapered one in twenty, has the advantage that it gives the rail the necessary inclination direct.

Our wedges, which may be of metal, can also, if necessary, be made of paper strongly compressed, or compounded, that is to say made of metal lined with compressed paper, in order to prevent the direct contact of metal with metal between the rail and the sleeper, a contact which gives disagreable sonorousness to the rails, *if owing to absence of proper adhesion blows could be produced*; in such cases the unloaded track has much more sonorousness.

However, we leave it to experiment to decide what would be best, knowing that fastenings with proper adhesion have no sonorousness.

Now whatever the system of manufacture adopted for the wedge, we have seen in chapter IV that the adhesion our fastenings require to possess must correspond to the greatest transverse force produced when the vertical force is least, and the latter may be nil; that is to say, our fastening must give the equivalent of 1,330 kilograms (2,932 lb.).

The wedge must, therefore, act between the rail flange and the sleeper, which are held together by the cramps, with a force Q so that

$$Q = 1{,}330 = P \tan(\alpha + 2\varphi) = P \frac{\tan \alpha + \tan 2\varphi}{1 - \tan \alpha \tan 2\varphi};$$

in this formula $\tan \alpha =$ the taper of the wedge $= 0{\cdot}05$ and $\tan \varphi =$ the coefficient of friction of iron on iron without lubrication $= 0{\cdot}40$, whence $\tan 2\varphi = \dfrac{2 \tan \varphi}{1 - \tan^2 \varphi}$

$= 0{\cdot}95$ in the case of the metal wedge, and $\tan 2\varphi = 1{\cdot}8$ in the case of the compressed paper wedge. Hence, as regards friction the latter is very suitable.

We will calculate the wedge on the assumption of metal surfaces.

We obtain P as follows :

$$1{,}330 = P \, \frac{0{\cdot}05 + 0{\cdot}95}{1 - 0{\cdot}05 \times 0{\cdot}95} = 1{\cdot}05P,$$

whence

$$P = 1{,}266 \text{ kilograms } (2{,}791 \text{ lb.}).$$

This will be obtained by using a hammer having such a weight that the maximum driving-in effect cannot be exceeded.

Theoretically, this pressure of 1,266 kilograms (2,791 lb.) distributed over the whole width of the flange, say 130 millimetres ($5\,{}^1/_8$ inches), by a key 185 milimetres ($7\,{}^9/_{32}$ inches) long, would give a compression of

$$\frac{1{,}266}{130 \times 185} = 0{\cdot}05 \text{ kilogram per square millimetre } (71{\cdot}11 \text{ lb. per square inch}),$$

a compression which with the maximum rail-load could amount to

$$\frac{1{,}266 + 7{,}400}{24{,}050} = 0{\cdot}3 \text{ kilogram per square millimetre } (426{\cdot}68 \text{ lb. per square inch}),$$

and with the maximum dynamic effect, to

$$\frac{1{,}266 + 17{,}760}{24{,}050} = 0{\cdot}8 \text{ kilogram per sq. millim. } (1{,}138 \text{ lb. per sq. inch}), \text{ the possible maximum.}$$

Practically the wedge, owing to irregularities of surface, will not bear uniformly. But this is of no importance, as 4 or 5 square centimetres (0·62 or 0·78 square inch) are quite enough for proper distribution, whereas we have 240 square centimetres (37·20 square inches) available, but when the rolling loads are passing, the rail and wedge will bear on the sleeper and the ballast, and we know that the vertical loads will increase the adhesion of the fastening *without in any way modifying* the initial pressure of 1,266 kilograms (2,791 lb.), as while the loads are passing the cramps will follow the movement of the flange, and after the loads have passed the cramps will be under the same conditions as regards resistance as before. The screw acts in the opposite way.

In other words, at every compression produced by a rolling load, the cramp acts as a spring, becoming unloaded as it follows the flange and resumes its state of strain after the train has passed ; whereas a screw shifts and is no longer able to give the same pressure.

It is hardly worth while to prove that the wedge cannot of itself shift in such a fastening ; to those who would think such a wedge could shift, we would reply that the force necessary to shift it would be :

$$Q' = P \tan (2\varphi - \alpha) = 1{,}266 \times \frac{\tan 2\varphi - \tan \alpha}{1 + \tan 2\varphi \tan \alpha};$$

whence

$$Q' = 1{,}266 \times 0{\cdot}85 = 1{,}076 \text{ kilograms } (2{,}372 \text{ lb}).$$

It would therefore require a force of 1,076 kilograms (2,372 lb.) to unloosen our wedge, when in its normal condition of tightness, maintained by the pressure of the cramps.

We have seen what a large margin of safety we have in the distribution of the load over the wedge; this is still greater in the case of the sleeper, as the wedge has a much larger bearing surface than the flange of the rail. It is, therefore, quite unnecessary to calculate the compression; we will only remark, that as our wedge is really a bed-plate which distributes the vertical forces over a large area, there is every advantage in using it in rail-fastenings in order to resist the transverse forces which are so injurious to the continuity of the track at the rail-ends.

b) MAINTENANCE OF PRESSURE IN OUR FASTENINGS.

The maintenance of pressure is effected by the cramps, which are true powerful springs, keeping up the pressure of 1,266 kilograms (2,791 lb.) between the flange and the sleeper, which is capable of resisting the maximum sliding forces possible, namely 1,330 kilograms (2,932 lb.).

We lay great stress on the point that the adhesion and strength of our fastenings is a result of the compression of the parts (just as in plates fixed together); our cramps therefore have *in no way to resist transverse forces.* All they do is to act *like true rivets* and maintain a pressure of 1,266 kilograms (2,791 lb.); *thus they only work in tension.*

But in addition to this pressure of 1,266 kilograms (2,791 lb.) given by the four cramps of a fastening, the two inner cramps will be subjected to additional stress as they prevent the rail from being canted by the horizontal force produced by the tires; we have estimated the resultant vertical force acting on the fastenings to amount to 1,680 kilograms (3,704 lb.) per fastening (*see* chapter IV).

Consequently the inner cramps have together to contribute in order to resist:

1° Horizontal sliding	633 kilograms	(1,396 lb.).
2° Canting	1,680 —	(3,704 lb.)
Total for the two cramps. . .	2,313 kilograms	(5,100 lb.).

Say 2,400 kilograms (5,290 lb.) for the two, or 1,200 kilograms (2,645 lb.) per inside cramp.

The two outside cramps have only to provide for half the vertical pressure necessary to resist horizontal sliding, namely $\frac{1{,}266}{2} = 633$ kilograms (1,396 lb.), or say 317 kilograms (698 lb.) per outside cramp.

We do not propose to profit fully from this very definite difference between the strength required by the outside and the inside cramps, for we think that an equal distribution such as that assumed can only exist theoretically.

Practically one cramp will always be more loaded than the other, and we must certainly keep well within the practical limit of elasticity of our springs.

That being so, we will only mark out the strength of the inside cramps.

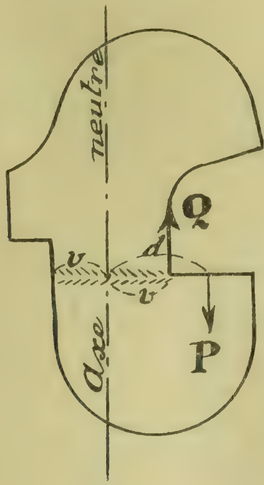

Fig. 7.

$Pd = Qv.$

Thickness of cramp = 20 millimetres ($^{25}/_{32}$ inch).

Explan tion of French terms : Axe neutre = Neutral axis.

The distribution of stresses in the cramp is shown in figure 7; there we see that the maximum strain is obtained from

$$Q = \frac{P \times d}{v}.$$

Now

P = 1.200 kilograms (2,645 lb.); d = 25 millimetres ($^{31}/_{32}$ inch), v = 10 millimetres ($^{25}/_{64}$ inch);

we therefore have

$$Q = \frac{1,200 \times 25}{10} = 3,000 \text{ kilograms (6,614 lb.)}$$

and

$$3,000 = R \times \frac{I}{v} = R\,\frac{bh^2}{6} = R\,\frac{20 \times 20^2}{6} = R\,\frac{8,000}{6}$$

whence

$$R = \frac{3,000 \times 6}{8,000} = 2{\cdot}25 \text{ kilograms per square mill. (3,200 lb. per sq. inch), working in tension.}$$

In compression, the metal of the cramp and that of the top of the sleeper will work at

$$\frac{1,200}{300} = 4 \text{ kilograms per square millimetre (5,689 lb. per square inch).}$$

We do not think it worth while to make any calculations as to the other parts of the fastening.

c) Rail-joints.

As rail-joint we have adopted the supported joint, laid on sleepers of the same kind, but the track to be with broken joints.

Vertical forces.

What in short we desire to obtain in our rail-joints, is the continuity of the rolling, under the same condition of elasticity as in the rest of the track.

Now as all the sleepers are supported in the same way, including the joint sleepers, we have only, in order that their bearing in the ballast should be the same as elsewhere, to allow for and to take into consideration the reduced tension in the fibres of the rail between the ordinary sleepers and the joint sleeper, and to make up for that reduction by the friction of the fishplates.

Now as the maximum rail-load is 7,400 kilograms (16,314 lb.), the maximum stress in the rail just over the sleeper, with the assumed sleeper-spacing of 68 centimetres (2 ft. 2 $^3/_4$ in.) cannot exceed

$$M = \frac{23}{72} \times 7,400 \times 0{\cdot}68 = 1,610 \text{ kilograms (3,550 lb.).}$$

We shall therefore have to design our fishplates so that their pressure will provide for this stress, which the rail ends just over the joint sleeper will not provide for.

If we assume a pair of fishplates held by five cotter-bolts, so as to obviate any working loose, we can determine the pressure of each of them as follows :

$$\frac{1,610}{(f = 0{\cdot}4) \times 5} = \frac{1,610}{2} = 805 \text{ kilograms (1,775 lb.).}$$

Each of these cotter-bolts, if the stress is not to exceed 5 kilograms per square millimetre (7,111 lb. per square inch), must have an effective cross-section to correspond. If we take bolts 30 millimetres (1 $^3/_{16}$ inch) in diameter (total cross-section 706 square millimetres [1·094 square inch]), with a cotter hole 6 millimetres ($^{15}/_{64}$ inch) wide, the effective cross-section will be 706 — 6 × 30 = 526 square millimetres (0·815 square inch), and the stress will be $\frac{805}{526} = 1{\cdot}5$ (2,133 lb. per square inch) approximately.

Transverse forces.

But in our opinion, the vertical forces are not the only important ones; the transverse forces have the more injurious effect of canting the trailing rail end more than the facing rail end, the latter being unloaded as long as the first wheel of the train has not passed over the joint (1).

What is therefore necessary, is that the rail ends at the joint should have as much resistance to canting as the rest of the rail.

Now the joint proposed is very suitable for this purpose, and the canting will be largely overcome by the resistance of the inside cramps, which are designed for a stress of 2·25 kilograms per square millimetre (3,200 lb. per square inch), and can without difficulty stand stresses of 5 and 6 kilograms per square millimetre (7,111 and 8,534 lb. per square inch), *provided that the joint can not open outwards.* It is for this reason that, dividing the thickness of the normal wedge into two, we have interposed between the wedge and the flange, at the joint, *a bed-plate of the exact width of the flange,* which prevents any lateral movement of the two ends.

Under these conditions, we give back to the joint the same strength vertically and laterally as is possessed by the rest of the rail, and this in our opinion is necessary for continuity of smooth rolling.

As a summary of this chapter we give the following table shewing the weights and maximum stresses of the different constituent parts of the track when subjected to wheel-loads of 14 tons (30,865 lb.) apiece.

Ballast :

$$\gamma = \frac{B}{D} = 2.$$

Maximum pressure of sleeper	2·6 kilog. per sq. centim. (36·98 lb. per sq. inch).
Minimum resistance laterally	1,504 kilograms (3,316 lb.) per sleeper.
— — to lifting.	255 — (562 lb.) —

Sleepers :

Weight of metal sleeper alone	50·8 kilograms (112·0 lb.).
— — — with fastenings. . .	57·7 — (127·2 lb.).
— — — with deadener blocks .	87·7 — (193·3 lb.).
Maximum stress, bottom (holes allowed for). .	5·9 — per sq. mill. (8,391 lb. per sq. inch).
— — top (— —) .	3·1 — — (4,409 lb. —).

Rails :

Minimum weight	40 kilograms per metre (80·63 lb. per yard).
— moment of inertia when worn down .	1,218 sq. centim. squared (29·26 sq. inches squared).

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(1) See Mr. Coüard's investigations.

Fastenings :

Weight of wedge	2·5 kilograms (5·5 lb).
Maximum compression (uniform distribution) .	0·3 kilog. per sq. millimetre (426·68 lb. per sq. inch).
Force holding together (adhesion)	1,330 kilograms (2,932 lb.).
— necessary for loosening.	1,076 — (2,372 lb.).
Weight of inside cramp	0·3 kilogram (0·66 lb.).
Maximum stress, inside cramp, tension . . .	2·25 kilograms per sq. mill. (3,200 lb. per sq. inch).
— — — — compression .	4 — — — (5,689 lb. —).
Weight of outside cramp	0·18 kilogram (0·40 lb.).
Maximum stresses, inside cramp, tension and compression	Under 1 kilog. per sq. mill. (1,422 lb. per sq. inch).

Joints :

Friction and fishplates, necessary for stiffness .	805 kilograms (1,775 lb.).
Maximum stress on cotter-bolts of fishplates .	1·5 — per sq. mill. (2,133 lb. per sq. inch).

VII. — Economy of proposed track.

Taking an average price (in France) for the sleepers as 180 francs per ton (£7.6*s*. 3·7*d*. per English ton), as except the cramps all in our proposed track can be made by simple rolling, the cost of per sleeper weighing 57·7 kilograms (127·2 lb.), comes to :

Metal part, 57·7 kilograms (127·2 lb.) at 180 francs per ton (£7·6*s*. 3·7*d*. per English ton) . . . . =	10·39 francs (8*s*. 3·74*d*.).
Two deadeners, 31 cubic decimetres (1·09 cubic foot) at 70 francs per cubic metre (1*s*. 7*d*. per cubic foot) . . . . =	2·17 — (1*s*. 8·83*d*.).
Total. . .	12·56 francs (10*s*. 0·57*d*.).

With the sleeper-spacing proposed, each kilometre of track will require

$$\frac{1,000}{0{\cdot}68} = 1,470 \text{ sleepers } (2,366 \text{ sleepers per mile}).$$

Assuming a wooden sleeper (¹) to have a life of ten years and to cost on the average 7 francs (5*s*. 7·2*d*.); a metal sleeper to have a life of twenty five years; the cost of labour for renewal to be 1 franc (9·6*d*.) in both cases; the annual cost of maintenance to be 500 francs (£32.4*s*. per mile) in the case of wooden sleepers and 300 francs (£19.6*s*. per mile) in that of metal sleepers; we obtain the following comparison :

(¹) See the reports of Mr. Kowalski, French Eastern Railway, Belgian Grand Central Railway, etc.

Comparative cost of a kilometre (of a mile) of track

with wood sleepers.		**with metal sleepers and deadener blocks.**	
Cost of annual purchases . .	$\frac{1{,}470 \times 7}{10}$ = 1,029 francs. ($\frac{2{,}366 \times 5s.\ 7{\cdot}2d.}{10}$ = £ 66. 5s.)	Cost of annual purchases. .	$\frac{1{,}470 \times 12{\cdot}56}{25}$ = 738 francs. ($\frac{2{,}366 \times 10s.\ 0{\cdot}57d.}{25}$ = £47.10s.)
Annual cost of labour of renewal	$\frac{1{,}470 \times 1}{10}$ = 147 francs. ($\frac{2{,}366 \times 9{\cdot}6d.}{10}$ = £ 9. 9s.)	Annual cost of labour of renewal	$\frac{1{,}470 \times 1}{25}$ = 59 francs. ($\frac{2{,}366 \times 9{\cdot}6d.}{25}$ = £ 3.15s.)
Annual cost of maintenance	= 500 francs. (£ 32. 4s.)	Annual cost of maintenance	= 300 francs. (£19. 6s.)
Total, purchase, renewal, maintenance . . .	1,676 francs. (£107.18s.)	Total, purchase, renewal, maintenance. . .	1,097 francs. (£70.11s.)
Less interest at 4 per cent on initial capital outlay, say 1,470 (12·56 — 7·00) or 8,173 fr. (2,366 × 4s. 5·37d. or £526.2s. 9·4d.) at 4 per cent	327 francs. (£ 21. 1s.)	Less value of old sleepers, say 3·5 francs (2s. 9·6d.), which gives per year . .	$\frac{1{,}470 \times 3{\cdot}5}{25}$ = 205 francs. ($\frac{2{,}366 \times 2s.\ 9{\cdot}6d.}{25}$ = £13. 2s.)
Annual expenditure. . .	1,349 francs. (£ 86.17s.)	Annual expenditure. . .	892 francs. (£57. 9s.)

That is an annual saving of 457 francs (£29.8*s.* 4*d.* per mile), which at 4 per cent represents a capital of 11,425 francs per kilometre (£735.9*s.* per mile) of track.

VIII. — Conclusion.

The whole system proposed provides for an adhesion between the rail flange and the sleeper, hitherto not obtained, and a reduction in the amplitude of the elastic movements of the rails, obtained by means of the deadener blocks.

This new system of track has received the name of the S track. The designer of this track has desired, by giving full explanations accompanied by the calculations involved, to enable all railway engineers to form an opinion on the value of the system proposed for the solution of a problem of the present day, the importance of which is well known.

If some errors have been overlooked, the author apologizes for them; it will be easy to correct them by substituting for any faulty figures other more accurate ones, but this will in no way modify the application of the two principles on which this investigation is based.

[621 .132.7 & 621 .335]

PETROL-ELECTRIC (MIXED TRACTION) LOCOMOTIVE ON THE BELGIAN STATE RAILWAYS FOR SHUNTING GOODS WAGONS,

By Em. UYTBORCK,

ENGINEER TO THE BELGIAN STATE RAILWAYS.

Figs. 1 to 3, pp. 418 to 420.

This memoir is a description of the mixed traction locomotive on the Pieper system, built by the *Compagnie internationale d'électricité* of Liége to the order of the Administration of the Belgian State Railways for shunting goods wagons.

This locomotive, which works on an entirely new system for shunting engines, was exhibited at the Milan Exhibition in 1906 before being put to work.

It will be seen below that the principal components of the locomotive are an internal combustion engine, a continuous current dynamo and a battery of accumulators.

The inventor has called this a mixed-traction locomotive because when it is working at maximum power, the propulsion of the machine is effected by the sum of the power exerted by the petrol motor and the power developed by the dynamo working as an electric motor.

It will be well to consider first some points in relation to the use of an internal combustion engine by itself for purposes of traction. The advantages of the new system will then be more readily grasped.

The internal combustion engine has the following peculiarities :

a) The necessity of being started beforehand;
b) Practically constant torque at all speeds;
c) Narrow range from maximum to minimum speed with good efficiency.

A motor of this class does not readily lend itself to a traction system dealing with very heavy loads. Its adoption would necessitate the use of clutches capable of being slipped for considerable periods, and of change gears which would be subjected to very frequent engaging when running at different speeds. Now it is just these difficulties which are met with in the design of such tractors, and the solution of these problems is far from being found in the case of really powerful motors.

The objection may be raised that the internal combustion engine is employed very successfully for automobiles. We should point out that it is usual to fit automobiles with motors of very high power compared to the weight of the vehicle : thus a motor car weighing 800 kilograms (1,764 lb.) is commonly fitted with a motor capable of developing 24 horse-power. If we keep the same proportion, what would be the horse-power of the motors required for a locomotive which is intended to haul a train weighing 300 tons (295 English tons)? 9,000 horse-power would be required as a maximum. Now the four cylinder motors usually built for automobiles seldom exceed 100 horse-power. The Wolseley Company of London has recently designed an internal combustion motor of 140 horse-power, for a railway motor-car, but such powers must be considered as the limit. The 24 horse-power of the automobile weighing only 800 kilograms (1,764 lb.) are not fully required except when the car is running up steep gradients, and particularly when accelerating at starting and after changing speed. At other times, the mean horse-power required rarely exceeds one third of the maximum horse-power. The flexibility of the motor is obtained at the expense of working it normally much below its maximum power. It follows therefore, that whereas the exclusive use of an internal combustion engine is perfectly satisfactory for the automobile, it is less so in the case of the motor omnibus, and becomes almost impracticable in the case of locomotives shunting heavy trains.

We should here state that we do not consider the adoption of the internal combustion motor by itself for purposes of traction on railways to be beyond possibility, but we find that motors of very high power and occupying little space, clutches and gear changing appliances suitable for such high power are not at present made and are yet to be designed.

We shall first briefly describe the principle on which the locomotive in question works; we will give a detailed description of the various parts later on.

The idea of Mr. Henri Pieper was to couple permanently the shaft of an internal combustion engine to a dynamo, which could be run at will either as a motor or as a generator. The addition of this dynamo immediately gives the petrol motor a flexibility which it did not previously possess, and moreover enables it to be worked at full load instead of at mean load.

When much power is required, the dynamo, supplied with current by the accumulators, acts as a motor and its power is added to that of the petrol motor. When the power required is approximately the maximum power of the petrol motor, the dynamo ceases to act as a motor. When the power required is less than the maximum power of the petrol motor, the dynamo acts as a generator, and the surplus power of the petrol motor is converted into electric energy and stored in the battery of accumulators.

The power available for traction may therefore vary from zero to the sum of those which the petrol motor and the electric motor can generate. The maximum power in the former is limited by the diameter of the cylinders and the stroke of the pistons, and in the latter, by the power of the batteries and the heating permissible in the windings. Assuming the battery of accumulators to be sufficiently large, the electric motor can generate during the short intervals of time required for accelerating, a power three to four times as large as it would be able to generate continuously. It is, therefore, to be expected that a mixed-traction locomotive will be able to perform shunting operations remarkably quickly.

The specification to which the builders were required to work was as follows :

A draw-bar pull of 2,000 kilograms (4,409 lb.) must be obtained for all speeds between 2 and 6 kilometres (between 1·2 and 3·7 miles) per hour. (The locomotive must be capable of running light at 9 kilometres [5·6 miles] per hour.) The weight of the locomotive must not be less than 20,000 kilograms (44,100 lb.). The capacity of the battery of accumulators must be sufficient to enable the locomotive to travel for half an hour at a speed of 2 kilometres (1·2 mile) per hour while exerting a draw-bar pull of 2,000 kilograms (4,409 lb.) without the assistance of the petrol motor.

Figure 1 is the locomotive shown in elevation; figure 2 shows it in plan.

The external appearance of the locomotive resembles the classical type of the Baltimore & Ohio Railroad. This type is moreover rational where the change of direction of running is as frequent as is required by the conditions of the present case.

One of the bonneted ends contains the petrol motor, and the other the battery of accumulators; the dynamo is fitted in the centre. This arrangement ensures an equal distribution of load on the two axles.

The petrol motor is of the single acting four cycle type with four cylinders each 120 millimetres (4 $^{11}/_{16}$ inches) diameter and 140 millimetres (5 $^{1}/_{2}$ inches) piston stroke.

This motor is designed to give 40 horse-power at 1,000 revolutions per minute; it can be run as low as 300 revolutions per minute.

A Sténhos carburettor is fitted to the motor. The makers guarantee the motor to run satisfactorily, even if it is fed with petroleum spirit of a density of 0·750. The possibility of using petrol of density 0·750 (which costs about one third of the price of the 0·680 spirit generally used) is simply a consequence of the fact that owing to the engine being started mechanically and turned rapidly by the electric motor, good carburation and satisfactory compression are obtained at once. As soon as the motor gets warm, the running is perfect and the power obtained is the same as that given with 0·680 spirit. All the valves are mechanically operated. The ignition is effected by means of high tension sparking plugs. The speed and power are controlled by advancing or retarding the ignition, and opening or closing the throttle on the induction. The ignition advance is obtained by connecting the advance rod to the single control lever of the locomotive.

The amount of gas supplied to the engine is automatically regulated by a throttle valve fitted in the induction pipe. This throttle valve is operated by the armature of a solenoid which has a double winding. One of the windings, of fine wire, is connected to the terminals of the dynamo; the other winding, of large diameter wire, is in circuit between the dynamo and the battery. The direction of flow in the windings is such that they act together when the battery is discharging, and against each other when the battery is being charged. The valve gives maximum opening for gas when the solenoid gives its maximum pull. From this arrangement, it follows that when much power is required of the locomotive, the admission of gas is the maximum (throttle full open) and, on the other hand, when the power developed by the petrol motor exceeds that necessary for traction the throttle is reduced.

The dynamo is shunt-wound with two brushes and eight poles. The doubling of the brushes is not due to difficulty in commutating, but to allow of series parallel coupling and thus obtain a wider range of speed and better utilisation of current.

The battery of accumulators is of the Tudor type of 88 cells in ebonite troughs. Each cell has a capacity of 65 ampere hours for a discharge period of half an hour. The cells can, moreover, be completely discharged in fifteen minutes without buckling the plates or deleterious heating. The weight of each pair of plates with the containing cell is about 15 kilograms (33 lb.).

The shaft of the dynamo is keyed to the shaft of the reversing gear. Magnetic clutches are used. The gear is shown in section in figure 3.

The shaft 1 of the dynamo is keyed to the shaft 5 of the reverse gear forming its continuation. At the ends of the shaft 5, are keyed two end discs 6 and 7 forming annular electromagnets which consequently revolve with, and at the same speed as, the dynamo. The electromagnet discs 6 and 7 can be excited so as to attract strongly the armature discs 3′ and 4′. The figure shows that the armatures are discs sliding on feathered sleeves which at the inside of the reverse gear box are cut with bevel teeth forming the bevel pinions 3 and 4. The sleeves revolve freely on the shaft 5. The pinions 3 and 4 are geared into the bevel wheel 2 which drives the locomotive through a double reduction gear. A third electromagnet disc 8 is fixed to the reverse gear box and so arranged as to be able to attract the armature disc 3′.

When the electric generating set is running, the electromagnet discs 6 and 7 are revolving and according as one or the other is excited the locomotive runs forward or backward. To put on the magnetic brake, the electromagnet discs 6 and 7 are cut out and the current is supplied to the electromagnet disc 8; the locomotive is then retarded by the friction of the moving disc 3′ against the fixed disc 8.

We have said that the transmission of power from the motor shaft to the wheels is effected by a double reduction gear. This has obviously the one object of increasing the tractive effort and diminishing the speed of the locomotive in the same ratio.

The double reduction gear transmits the motive power to a central cross shaft which carries at its ends two shafts keyed at 90° to each other.

The pins of these crank arms fit into coupling rods which connect the driving axles. This arrangement has been employed on some locomotives on the three

Figs. 1 and 2. — *Mixed traction locomotive for shunting goods wagons on the Belgian State Railways.*

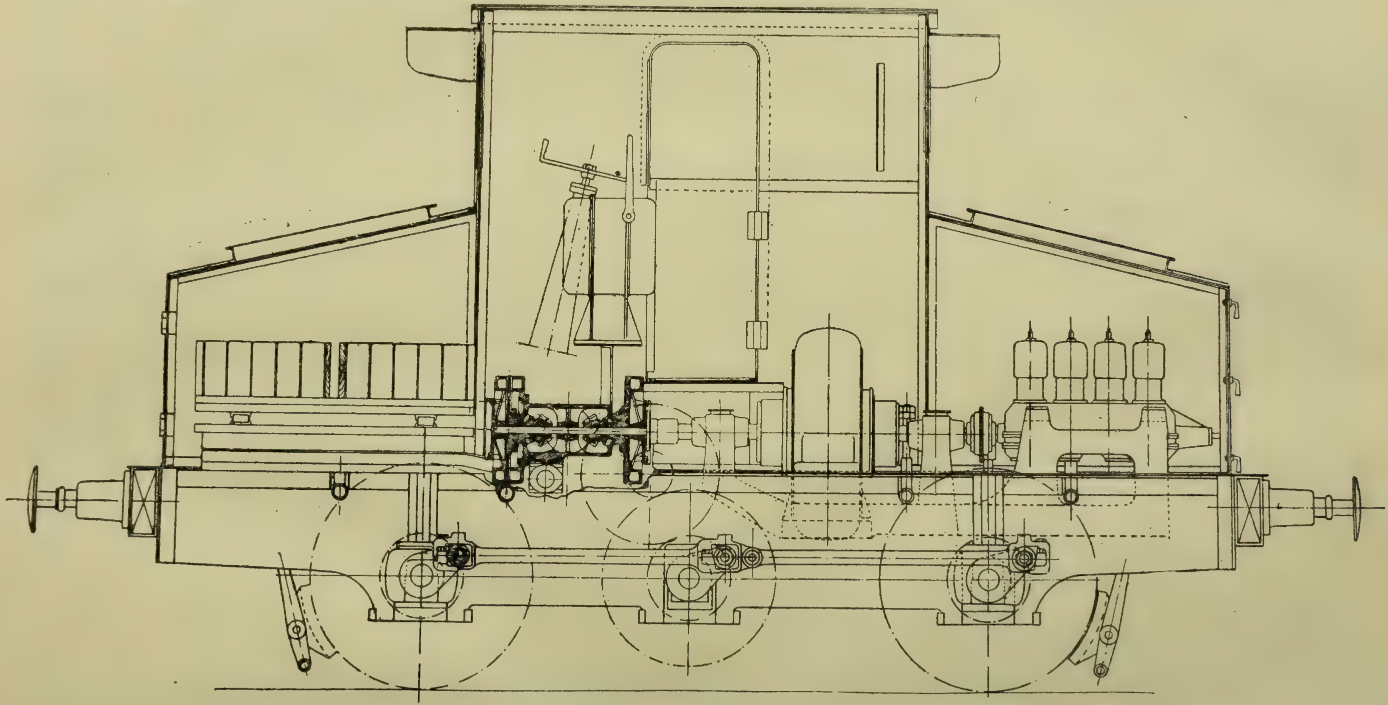

Fig. 1. — Elevation.

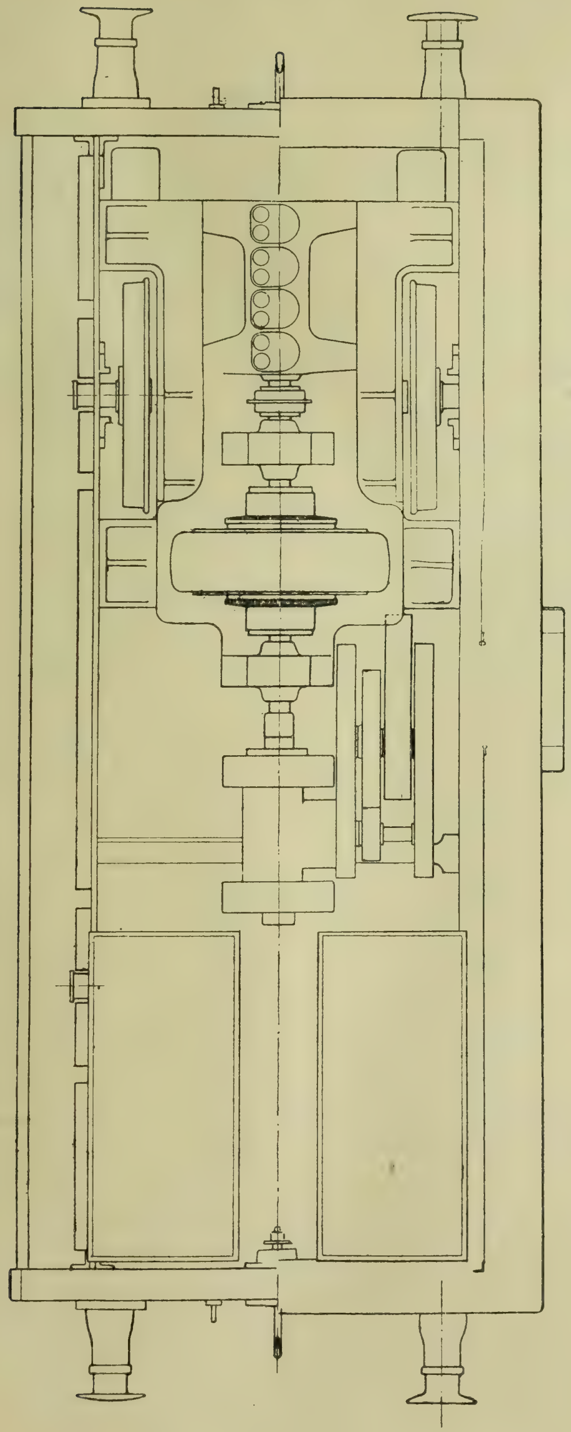

Fig. 2. — Plan.

phase line at Valteline and on the locomotives recently designed for running through the Simplon tunnel.

In the present case it offers the following advantages :

1° The possibility of arranging the several components rationally;

2° The possibility of employing a single electric motor for driving both axles, and at the same time utilising the whole weight of the locomotive advantageously for obtaining adhesion.

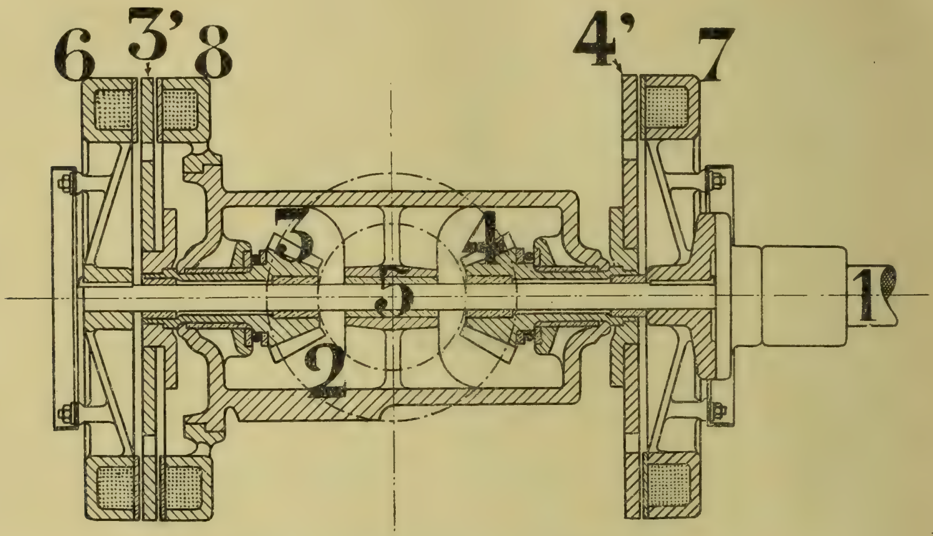

Fig. 3. — Section through the reversing gear.

It is to be noted that if the drive were taken to one of the axles through the double reduction gear and this axle coupled to the other by ordinary coupling rods, the adhesion would not be nearly so good. In this case, the play which necessarily exists in the bearings at the ends of the coupling rods, would produce the following results : if the driving wheels slip to a very small extent, the adhesion of both pairs of wheels becomes effective; if the driving wheels do not slip, the other wheels are simply driven. Now in the case under consideration, it is alternately one and the other pair of wheels which are the drivers. As this function changes twice in each revolution of the wheels, it follows that slipping is less to be feared than in the previous case. The arrangement in fact affords a solution to the general problem of driving any tractor by means of a motor carried by the frame : “ Rigid mechanical connection between the driving mechanism and the frame, the whole being carried on the axles through the medium of suspension springs. ”

To start the locomotive, it is necessary first to use the dynamo as an electric motor. To do this, a starting rheostat is used which is fitted with cutouts for excess or absence of current; this completes the battery circuit through the dynamo, and causes the crankshaft of the petrol motor to rotate. By the same movement, the petrol motor ignition switch closes its circuit. The petrol motor now starts firing, the set gets up to speed, and the voltage at the dynamo terminals rises above the voltage of the battery. The direction of the current through the dynamo becomes reversed, that is to say, the petrol motor drives the dynamo instead of being driven by it. The speed attained depends on the grouping in series of the dynamo windings and on the maximum quantity of exciting current.

A controller makes the necessary connections for starting and braking the locomotive. The handle of the controller can occupy a series of positions symmetrically on each side of the mid-position, those on the one side relating to forward running, and those on the other side to backward running. In passing from the mid-position to the end of the travel, the following takes place:

a) The electromagnet disc 8 is excited; this has no effect as the locomotive is still at rest;

b) The current is cut off the electromagnet disc 8, and the electromagnet disc 6 (for example) is excited. This results in gradual application of the power and the locomotive starts; the generating set slows down, and the current from the battery flows through the dynamo which now acts as an electric motor, the power which it gives assisting the petrol motor. Little by little as the locomotive gains speed, the speed of the motor becomes greater and the voltage at the dynamo terminals rises, the current supplied by the battery falling accordingly;

c) Gradual reduction in the exciting current of the dynamo. This reduction results in a drop of voltage at the terminals of the dynamo, and causes more current to flow through it. The final result being an increase of speed;

d) The two windings of the dynamo are put in parallel and the exciting current increased to the maximum; this has the same effect as the preceding;

e) Gradual reduction of the exciting current, with the same result.

It is, therefore, only necessary to push the handle of the controller gradually from the mid-position to one of the extreme positions, in order to apply the clutch to the driving gear of the locomotive by degrees and accelerate it to its maximum speed.

Conversely, when passing from one of the extreme position to the mid-position, the first step is to increase the quantity of the exciting current of the dynamo which causes the voltage at the terminals to rise, and increases the quantity of current generated. This results in a braking action owing to work being done on the dynamo, and a recuperation of electric energy which is stored in the battery. In succession the switch passes from the parallel contact to the series contact, the exciting current being diminished and then gradually increased after the change. Finally, to bring the locomotive to rest, the current is cut off the electromagnet disc 6 and the brake electromagnet disc 8 is excited.

It will be seen from the above description how easily this somewhat complex arrangement is controlled and how little tuition is necessary to enable one to operate it.

The locomotive is so arranged that, if it is necessary, the batteries can be charged by the electric generating set; so that it can be run on the battery alone or by the petrol motor alone.

The locomotive was exhibited at Milan with a temporary starting controller, but the controller which will be finally fitted will be on the principle explained above.

Time did not permit of making complete trials of the new locomotive before it was sent to Milan. The Administration of the Belgian State Railways intends to proceed with a series of trials as soon as the locomotive returns to Belgium, and the new tractor is to be used in stations where a steam locomotive would not be sufficiently occupied and where the adoption of an electric locomotive deriving its supply from an overhead wire would, not appear advantageous, owing to the difficulties of installing the overhead wires for the supply of current.

[625 .143.3]

NOTE

ON THE WEAR OF RAILS,

By Léon de LUBIMOFF,

CHIEF ENGINEER AND ASSISTANT MANAGER OF THE RUSSIAN NICOLAS RAILWAY.

Figs. 1 to 6, pp. 429 and 430.

(*Organ für die Fortschritte des Eisenbahnwesens.*)

One of the most important problems the permanent way engineer has to deal with, is to determine all the conditions which can lead to the shorter life of rails, so that he may counteract them. Unfortunately this is a matter of very great difficulty; it involves the consideration of a large number of different factors which are seldom combined in the same manner, and consequently statistical data applying to conditions sufficiently similar to be comparable are seldom available.

In order to contribute to the solution of this problem, the author gives below the results of some of his observations on the life, the wear and the quality of the rails used on the Russian railways.

The Russian railways, which at present have a total length exceeding 65,000 kilometres (40,400 miles), have during the last few years only used rails of Russian manufacture. But they have not yet satisfactorily solved the question of determining what mild steel is the best, from the technical point of view, and the safest to use. Some twenty years ago, it was already recognized that it was wrong to use too soft steel, as such rails became worn out comparatively quickly. The different managements repeatedly expressed the desire to have much harder steel. But on the one hand, as the proceedings of the last sessions of the International Railway Congress show, it is as yet not proved what the best hardness for rails should be; on the other hand, owing to the defective organization of the method of giving orders, no competition existed between Russian rolling mills. As a result, during the last few years (1900 to 1905) rail steel has been even more unsatisfactory than before, in some cases very much so; the government has, therefore, just appointed a commission to draw up the best possible specifications for rail steel.

The present article is one of the contributions to this work; it may also be of interest, to the railways of other countries, on account of its special object, which is to determine what relation there is between the hardness of rail steel and its other mechanical properties.

I. — Manufacture of the rails.

It is well known that the steel of rails resists wear and tear best if it is homogeneous and dense, and free from flaws. It is, therefore, necessary to obtain steel of sufficient hardness and tenacity, having also the necessary homogeneity and uniformity of composition. When rails are manufactured by the processes carried out in Russia, it is very difficult to satisfy these conditions, more especially because most of the rolling mills use Bessemer or Thomas steel (steel made in a converter), and very few use the Siemens-Martin process, as this takes longer and is consequently more expensive, although the latter process is superior as regards homogeneity and uniformity of composition.

II. — Specification.

Starting from the assumption that comparatively soft steel can be prepared in a purer condition than hard steel, and that the purity of the metal is the best guarantee for satisfactory service and for the absence of the much-feared chance of fracture, the ultimate tensile strength R (which also serves as a measure for the hardness) has been lowered, in the Russian specifications, to 60 kilograms per square millimetre (85,337 lb. per square inch); the elongation i is fixed at at least 6 per cent. The ultimate tensile strength plus double the elongation, that is $R + 2i$, is to be not less than 82. In addition to the tensile tests, all the Russian railways also specify bending and drop tests.

III. — Wear of the rails.

Although the rails supplied between 1900 and 1905 satisfy the specifications perfectly, they show wear which is both considerable and irregular, and result in the following defects :

1° The head becomes crushed, not only at the joint, but also at other points along the rail. The gaps at the joints soon become filled up, as a result of this crushing. Many instances have been observed where flattening to the extent of 8 millimetres ($^5/_{16}$ inch) has taken place;

2° Depressions in the rolling surface, forming hollows; these are probably due to the closing up of blow-holes;

3° Cracks 3 to 4 millimetres ($^1/_8$ to $^5/_{32}$ inch) deep and up to 1 metre (3 ft. 3 $^3/_8$ in.) long; these appear during rolling and are caused by the presence of slag, or of particles of the lining of Bessemer converters, or of particles of unconverted or of oxidised iron;

4° Lamination; up to twelve layers become separated;

5° Cracks, and even cavities, in the cross-section of the rail; the result of not cropping the upper ends of the ingots sufficiently;

6° Bends, due to defective straightening, or even to straightening in the cold.

These defects are the result either of want of homogeneity or of defective rolling. They all occur to an exceptionally marked degree in the rails recently rolled for the St. Petersburg-Moscow and St. Petersburg-Warsaw lines; these are rails with high massive heads, and weigh 43 kilograms per metre (86·68 lb. per yard). To the faults already mentioned must be added too hot rolling for the inside of the head and unequal cooling.

IV. — Does the quality of the steel for rails depend on its tensile strength?

When the irregular and defective wear of the rails which had satisfied all the specified tests had made itself so very apparent, the question then arose whether great tensile strength was a certain guarantee for the quality of steel for rails. The reasons given below lead to an answer in the negative.

Bending and drop tests nearly always show whether the quality of the steel for rails is sufficiently good. But tensile tests by themselves do not always give certain information as to quality, particularly not if made on test pieces not previously subjected to any drop test. This is readily intelligible. In bending and drop tests, the whole cross-section of the rail is subjected to stress, whereas in the case of tensile tests the results depend largely on other conditions : local internal strain, want of accurate adjustment in setting the test pieces in the testing machine, local defects in the test pieces ; so that rails which have given very good results in the way of tensile tests may nevertheless give very bad results in practice.

Table I gives some results bearing on this point.

Table I.

NAME OF RAILWAY.	MANUFACTURER.	Ultimate tensile strength, R, kilograms per square millimetre (lb. per sq. inch) (1).	Elongation, *i*, per cent (1).	R + 2*i* (1).	*Remarks of management concerned, on results obtained.*
Russia.					
State Railway : Baltic line . .	Putiloff, St. Petersburg.	62·0 (88,181)	17·1	96·2	Very bad rail.
State Railway : Catherine line.	Brjansk, Iekaterinoslav.	62·9 (89,462)	17·9	98·7	One of the worst rails.
	New-Russia, Iekaterinoslav.	62·13 (88,366)	13·0	82·0	One of the worst rails.
Pleskau-Ribinsk Railway Co .	Putiloff, St. Petersburg.	66·2 (94,155)	23·6	113·4	The fracture of the rail caused a derailment.
State Railway : Transcaucasus line.	Druschkower, Kharkoff.	70·4 (100,129)	16·4	103·2	Dangerous cracks and flaws.
Moscow-Vindau Railway Co.	Bogoslow, Ural.	82·3 (117,054)	11·1	104·5	Sudden fracture.

(1) Determined at the Imperial Testing Laboratory Institute of Ways and Communications.

V. — Does the risk of fracture of rail steel increase with the hardness?

In Russia, as in many other countries, soft steel was adopted as the material for rails, because it was assumed that the use of such steel gave the best guarantee against risk of fracture. However hard steel, very hard steel even, is by no means dangerous, if it contains no foreign substances such as phosphorus, copper, etc. In this connection Russia, particularly Russia in Asia, can give much information, as climatic conditions and local peculiarities are exceptionally varied in character. Temperatures varying between +62° C. (+144° Fahr.) in summer and —62° C. (—80° Fahr.) in winter, as in Siberia, and variations of over 38° C. (68° Fahr.) in less than eighteen hours (1), and large and frequent movements in the soil produced by the cold are certainly serious factors calculated to produce serious and very injurious stresses in the steel of the rails. Nevertheless very hard, but carefully rolled, rails stand these unfavourable conditions very well, often better than rails made of softer steel; at the same time, they become worn more slowly and more regularly than the latter.

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(1) For instance at Tomsk, in Siberia, on a day in December 1902, it was —58° C. (—72° Fahr.) in the morning, and —20° C. (—4° Fahr.) in the evening of the same day.

This has been clearly shown by the striking observations made on the English rails of the Siberian Railway, weighing 29·8 kilograms per metre (60·07 lb. per yard); they were delivered in 1894 by Captain Wiggins at the mouth of the Jenissey and brought by boat to the town of Krasnoiarsk, where they were laid on a length of 17 kilometres (10·56 miles) of the Siberian Railway. These rails, which are of very hard steel, have given excellent results till now. During the eight years, 1894 to 1902, more than 9,000 rail fractures occurred on the Siberian Railway; of these only two occurred in Wiggins rails. We had previously observed the same immunity from fracture in very hard English rails, in the case of rails supplied by Messrs. Wilson and Cammell, containing up to 0·84 per cent of carbon, and laid 1870-1875 on the Moskow-Kursk and Nicolas lines.

If the platelayers attend to their duties conscientiously, the fracture of rails, so much feared, only rarely produces derailments; that is at least the case in Russia, where it seldom happens that fracture takes place suddenly under the wheels of a passing train. At the spot where the the rail is defective, a fine crack first appears or irregular wear becomes apparent; the permanent way men, if properly attentive, can readily discover this. It is only subsequently, after several trains have run over the damaged place, that fracture proper takes place. Consequently, it is possible to eliminate, in good time, the risk of derailment.

The statistics of rail fractures in Russia lead to the following conclusions :

1° In eight years there were, on the Siberian Railway, more than 9,000 rail fractures; these produced altogether only eight derailments;

2° In ten years there were, on the Moscow-Kursk line, 1,725 rail fractures, causing only one derailment;

3° In the last five years there were, on the Nicolas Railway (St. Petersburg-Moscow line), 1,374 rail fractures, causing only one derailment. Very hard rails only accounted for 4 per cent of these fractures.

The small number of derailments is due more especially to the relatively good organization of the permanent way service; rewards of 2 to 3 marks (2*s.* to 3*s.*), in Russia in Europe, and of 5 marks (5*s.*), in Russia in Asia, are paid for the discovery, in good time, of a rail fracture.

VI. — **Results of observations made on rails placed under absolutely identical conditions.**

The reasons mentioned in chapters II to IV, and the desire to make observations under as comparable conditions as possible, led to the construction of an experimental section with steel rails, on which all the essential conditions were absolutely identical for all the rails which were to be tried. These conditions were : 1° profile and plan of the track; 2° road-bed; 3° ballast; 4° type of track and its maintenance; 5° cross-section of rail; 6° speed; 7° rolling loads. At the request of the Imperial Russian Technical Association, this experimental section was laid down in 1889 on goods line IV, at kilometre 10 of the Nicolas Railway, between St. Petersburg and Obouchowo stations. All the trains from Moscow to St. Petersburg run over this line. One hundred and ninety rails, 5·19 and 4·34 metres (17 ft. 3/8 in. and 14 ft. 3 in.) long, were supplied by the different Russian rolling mills, as follows :

Beloselsky works, Ural	40 rails.
Demidoff works, Ural	30 —
Brjansk works, Orel	30 —
Putiloff works, St. Petersburg	30 —
New Russia works, Jekaterinoslaw	30 —
Bankowa works, Poland.	30 —

The rails from these different works were laid on the following dates :

Bankowa	16th	November,	1889.
New Russia	17th	—	—
Putiloff	18th	—	—
Brjansk	19th	—	—
Demidoff	20th	—	—
Beloselsky	21th	—	—

The rails weighed 31·74 kilograms per metre (63·98 lb. per yard); they were all mild steel. The line is straight, and has a rising gradient of 1·5 per mil; the coefficient of ballast C may be estimated as = 4. Brakes are not used on the experimental section. The rails were laid on wooden sleepers, with suspended joints and ordinary angular fishplates with iron bed plates on each sleeper. Spikes made of very mild steel were used; each rail was numbered and a board bearing the name of the manufacturer was placed at the end of each set of rails.

In order to have reliable data as to the progressive wear of the rails, it was determined to measure them twice a year, and to ascertain the gross load which had run over them during the corresponding period. The Kraft apparatus (fig. 1) was used for this purpose; the verniers enable the head to be measured at nine points.

Unfortunately however, it was not possible to take these half-yearly measurements as originally intended, and from 1889 to 1903 only three sets of measurements were taken. The first was in September 1890; the second in June 1898; and the third in August and September 1903. All the figures obtained were duly recorded in a book. During these fourteen years, out of the hundred and ninety rails only three had to be taken out, two (Beloselsky and Demidoff) on account of fracture, the first in 1901, the second in 1903, and one because a crack occurred in the head and in the flange.

When we examined the data so obtained, some of the figures seemed rather remarkable. This induced us to make fresh measurements of the whole experimental section in June 1904. These measurements were made by means of Koslowsky's cross-section delineator.

This apparatus, shown in figure 2, consists of a jointed frame K fixed to the base P; the frame is secured in position by the five screws S_1, S_2, S_3, S_4 and S_5. The frame holds rows of needles sliding longitudinally; when the screws are not drawn up tight, the needles can be pushed into contact with the railhead and then secured in position by tightening the screws. At the back each needle has a point fixed at right angles. When this apparatus is used, it is taken in the left hand, the screws S are loosened, and the base P is secured to the flange of the rail by means of the screws L_1 and L_2. Then the needles are pushed till they are in contact with the railhead, and the screws S tightened. L_1 and L_2 are then loosened and the cross-section as shown by the needles is then pricked into paper; this showed the contour of the railhead which was to be measured.

The gross load which had run during the 14·5 years in question over the experimental section amounted to 48 million tons (45·3 million English tons). The measurements made gave the following results :

A. The maximum wear of the railhead, in height, was 3·75 millimetres (0·148 inch), or 0·079 millimetre per million tons (0·00316 inch per million English tons) of gross load.

B. The maximum wear of the railhead, on the side, was 2·25 millimetres (0·089 inch), or 0·04 millimetre per million tons (0·00160 inch per million English tons) of gross load.

C. The maximum lateral deformation of the railhead was 3·5 millimetres (0·138 inch), or 0·073 millimetre per million tons (0·00292 inch per million English tons) of gross load.

These figures do not show greater wear and tear than might have been expected.

D. Taking all the 190 rails into consideration :

80·5 per cent show wear, in height, of not more than 0·052 millimetre per million tons (0·00208 inch per million English tons) of gross load;

58·9 per cent show wear, on the side, of not more than 0·02 millimetre per million tons (0·00080 inch per million English tons) of gross load;

19 per cent show no wear on the side;

31·5 per cent show no deformation;

54·7 per cent show a lateral deformation of not more than 0·03 millimetre per million tons (0·00120 inch per million English tons) of gross load.

E. Chemical analysis shows that the carbon content of the better rails is at least 0·39 per cent, and as a maximum 0·77 per cent. The corresponding figures for the inferior rails are 0·28 and 0·52 per cent respectively.

F. Brinell's hardness test gives B = 219·75 (312,546 lb. per square inch) as a maximum and B = 154 (219,031 lb. per square inch) as a minimum.

As these statements do not fully exhibit the mechanical properties of the steel, they are supplemented by the particulars given in tables II and III. With regard to these, the following observations may be made :

The rails which show but little wear, have a ratio $\alpha = \frac{R'}{R}$ not less than 0·45, average 0·59; but among rails showing more wear there are also rails with $\alpha > 0{\cdot}50$, but the average is $\alpha = 0{\cdot}50$.

The variations are great, but the results at least prove that good rails always have a large ratio α, but that the presence of such a ratio is not always a guarantee that the rails are good.

The limit of elasticity R′ is between 32·25 and 46·30 kilograms per square millimetre (between 45,870 and 65,850 lb. per square inch) in the case of rails showing less wear; in the case of the rails showing more wear it is between 23·90 and 37·90 kilograms per square millimetre (between 33,990 and 53,900 lb. per square inch). But it should be noted that the rails showing more wear have on the whole behaved satisfactorily.

This shows that the limit of elasticity taken by itself does not show the suitability or unsuitability of a rail. But as rails on a track are subjected to very high stresses (up to 40 kilograms per square millimetre [56,890 lb. per square inch]) and as the limit of elasticity R′ is below 40 kilograms per square millimetre in the rails of table III, and is also smaller, on the average, in these rails than in the rails of table II, it appears advisable to specify some lower limit for the

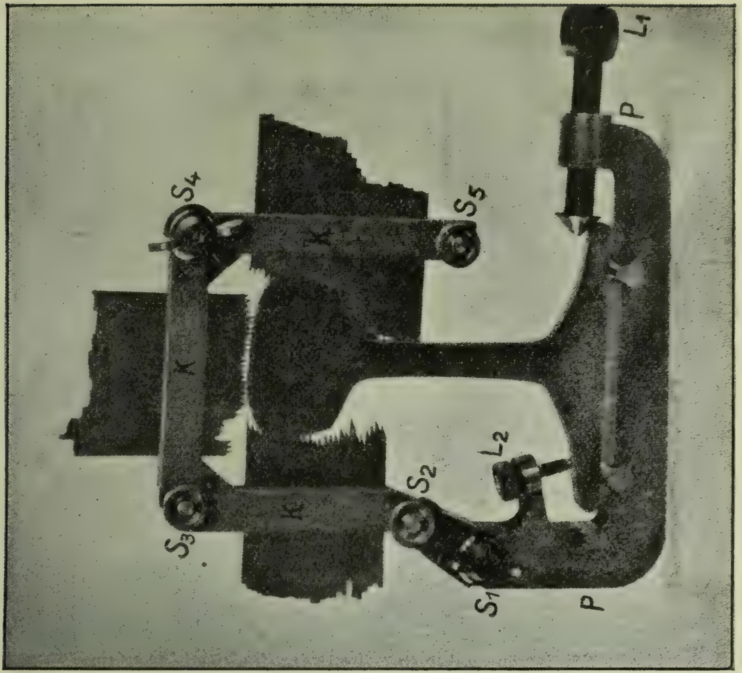


Fig. 2.

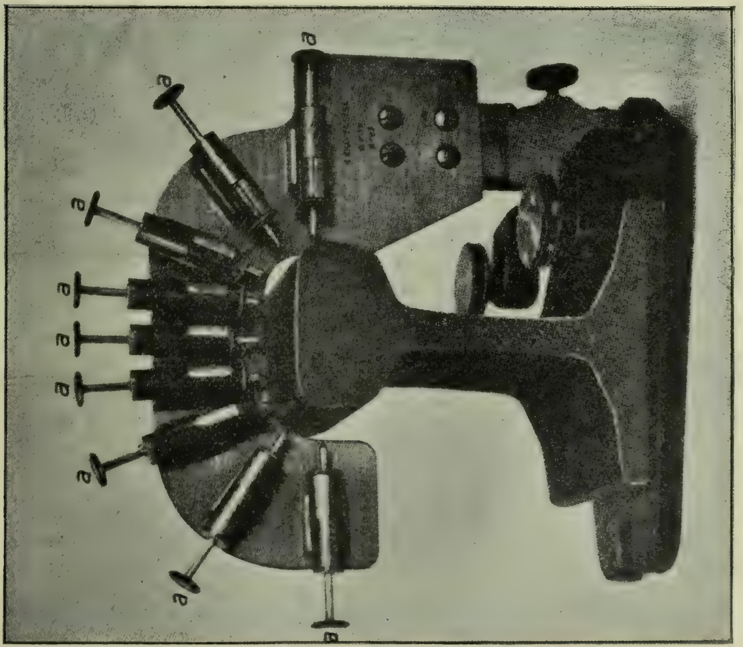


Fig. 1.

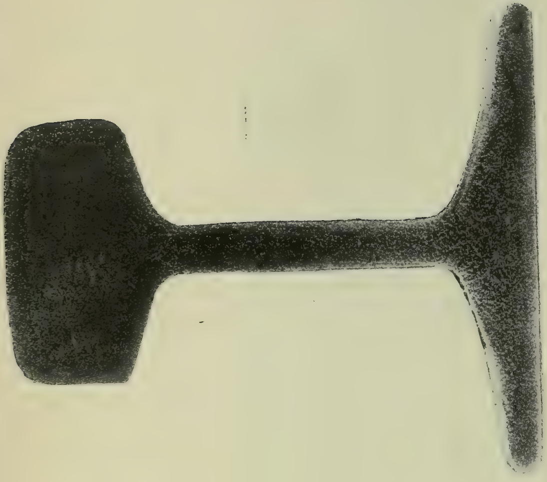


Fig. 4.

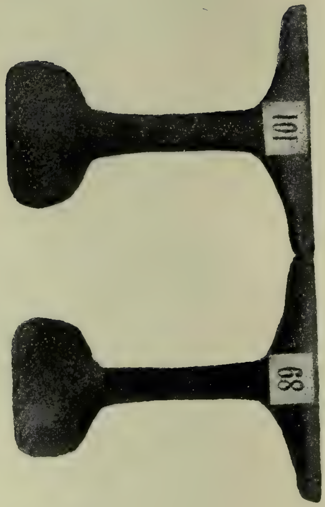


Fig. 6.

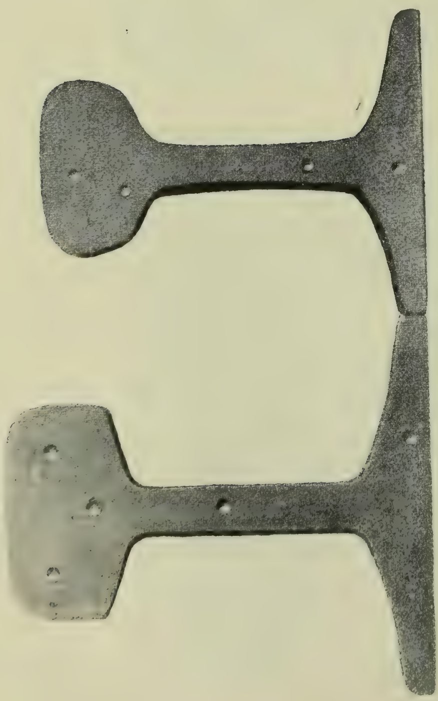


Fig. 3.

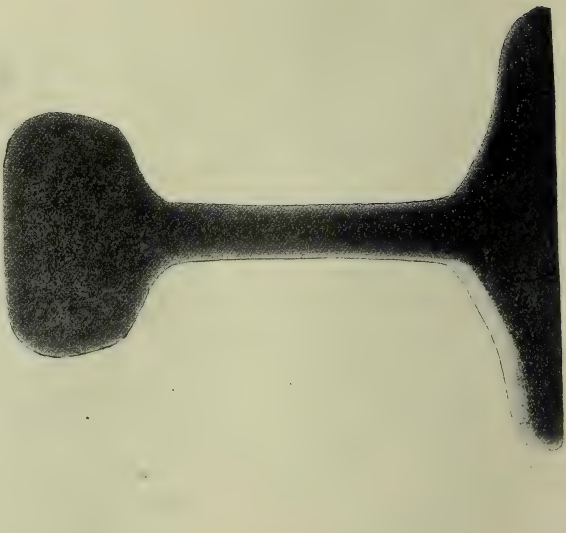


Fig. 5.

Table II.

Rails of the Technical Association, showing little wear.

Index number.	Number given by Technical Association.	MANUFACTURER.	CHEMICAL COMPOSITION, PER CENT.			Wear per million tons of total load, millimetres (inches per million English tons).	Hardness according to Brinell, kilograms per square millimetre (lb. per sq. inch), B.	Ultimate tensile strength, kilograms per square millimetre (lb. per sq. inch), R.	Cœfficient of quality, R + 2 *i*.	Limit of elasticity, kilograms per square millimetre (lb. per sq. inch), R'.	Ratio $\alpha = \frac{R'}{R}$.	*Remarks.*
			C.	Mn.	Ph.							
45	187	Demidoff.	0·65	0·37	0·076	0·026 (0·00104)	...	43·40 (61,727)	46·60	36·30 (51,629)	0·83	
46	172	—	...	...	...	0·036 (0·00144)	...	65·60 (93,302)	74·60	37·50 (53,336)	0·57	
48	168	—	...	...	...	0·026 (0·00104)	...	58·25 (82,848)	98·15	32·25 (45,869)	0·55	
49	182	—	0·63	0·39	0·075	0·042 (0·00168)	...	57·90 (82,350)	60·20	37·45 (53,264)	0·64	
52	181	—	...	...	...	0·026 (0·00104)	...	56·70 (80,643)	60·00	43·00 (61,158)	0·75	
57	171	—	0·51	0·41	0·073	0·021 (0·00084)	...	61·95 (88,110)	72·85	40·85 (58,100)	0·66	
63	174	—	...	...	...	0·026 (0·00104)	...	63·25 (89,959)	69·65	39·50 (56,180)	0·62	Mean value
68	167	—	0·39	0·45	0·092	0·026 (0·00104)	167·25 (237,877)	60·70 (86,333)	94·00	33·15 (47,149)	0·54	of α = 0·59.
73	127	Brjansk.	0·51	1·06	0·07	0·042 (0·00168)	219·75 (312,546)	79·15 (112,574)	112·85	38·90 (55,327)	0·49	
74	129	—	...	...	...	0·021 (0·00084)	...	77·95 (110,867)	106·65	44·65 (63,505)	0·57	
78	122	—	...	...	...	0·026 (0·00104)	...	62·70 (89,177)	104·80	34·80 (49,495)	0·55	
80	109	—	0·47	0·63	0·06	0·042 (0·00168)	209·75 (298,324)	74·50 (105;960)	110·00	39·05 (55;540)	0·52	
84	110	—	0·46	1·12	0·07	0·026 (0·00104)	...	74·40 (105,818)	112·90	42·60 (60,589)	0·57	
85	128	—	...	...	...	0·026 (0·00104)	...	82·50 (117,338)	108·60	46·30 (65,852)	0·56	
116	68	Putiloff.	0·77	1·16	0·08	0·036 (0·00144)	...	92·65 (131,774)	113·65	41·85 (59,523)	0·45	
178	158	Bankowa.	...	...	...	0·042 (0·00168)	...	78·75 (112,005)	108·55	40·30 (57,318)	0·51	

Table III.

—

Rails of the Technical Association, showing much wear.

Index number.	Number given by Technical Association.	Manufacturer.	Chemical composition, per cent.			Wear per million tons of total load, millimetres (inches per million English tons).	Hardness according to Brinell, kilograms per square millimetre (lb. per sq. inch), B.	Ultimate tensile strength, kilograms per square millimetre (lb. per sq. inch), R.	Cœfficient of quality, R + 2*i*.	Limit of elasticity, kilograms per square millimetre (lb. per sq. inch), R′.	Ratio $\alpha = \frac{R'}{R}$.	*Remarks.*
			C.	Mn.	Ph.							
8	3	Beloselsky.	0·32	0·39	0·08	0·073 (0·00292)	156·00 (221,876)	56·50 (80,359)	98·10	23·90 (33,993)	0·42	
11	11	—	...	...	...	0·079 (0·00316)	..	64·10 (91,168)	97·60	34·85 (49,567)	0·52	
16	13	—	...	...	...	0·079 (0·00316)	...	56·10 (79,790)	100·30	28·80 (40,962)	0·51	
22	18	—	...	...	...	0·063 (0·00252)	188·25 (267,745)	63·45 (90,244)	98·45	30·00 (42,668)	0·48	
29	21	—	0·28	0·13	0·06	0·063 (0·00252)	...	53·00 (75,381)	93·20	27·20 (38,686)	0·51	
30	8	—	...	...	...	0·063 (0·00252)	154·00 (219,031)	53·95 (76,732)	85·35	30·10 (42,811)	0·55	Mean value
131	88	New Russia.	...	...	...	0·063 (0·00252)	...	72·85 (103,613)	106·95	37·80 (53,762)	0·52	of $\alpha = 0.50$.
136	81	—	0·49	0·36	0·08	0·063 (0·00252)	211·00 (300,102)	74·05 (105,320)	103·05	33·55 (47,718)	0·45	
139	80	—	...	...	...	0·063 (0·00252)	...	66·90 (95,151)	109·10	36·95 (52,553)	0·55	
145	82	—	. .	...	. .	0·130 (0·00520)	...	73·50 (104,538)	106·05	37·90 (53,904)	0·51	
157	73	—	0·44	0·82	0·115	0·073 (0·00292)	...	66·39 (94,435)	103·65	35·10 (49,922	0·53	
168	154	Bankowa.	0·52	0·87	0·04	0·063 (0·00252)	219·75 (312,546)	79·40 (112,929)	111·10	38·00 (54,017)	0·48	

limit of elasticity; for the preceding argument shows that a high limit of elasticity is a property all good rails have, and consequently it may serve as a guide to the quality of rails.

VII. — Observations made on some rails of the Nicolas Railway.

The observations considered in chapter VI led to the examination of the behaviour of rails placed under as similar conditions as possible. Ninety rails were examined which were taken out of the main line of the Nicolas Railway during renewal in 1904. These rails had been in use for from thirteen to thirty-five years on a straight level section or on rising gradients of less than 4·5 per mil. Gross loads of from 33 to 161 million tons (32·5 to 158·5 million English tons) had run over them. The loss of weight of these rails was determined in St. Petersburg, and their cross-sections measured by the Koslowsky apparatus. The rails were supplied by the works mentioned in table IV.

Table IV.

Index number.	MANUFACTURER.	Total load, millions of tons (millions of English tons).	Index number.	MANUFACTURER.	Total load, millions of tons (millions of English tons).
1	Demidoff	80 (78·7)	6	Charles Cammell . .	91 (89·6)
2	Brjansk	89 (87·6)	7	Guest.	91 (89·6)
3	Putiloff	79 (77·8)	8	Dixon.	34 (33·5)
4	New Russia	50 (49·2)	9	John Brown . . .	70 (68·9)
5	Wilson & Cammell. .	161 (158·5)	10	Schneider	40 (39·4)

The more interesting results of these observations are given in table V, which gives, for twenty-five of these rails, the local conditions, the position, the life, the loss of weight, and other particulars. These results lead to the following conclusions :

The greatest wear among these twenty-five rails is less than 0·05 to 0·1 millimetre per million of tons (0·00200 to 0·00400 inch per million of English tons) of gross load, which is the admissible wear on gentle gradients.

The greatest wear among the rails supplied by the Russian mills Demidoff, Putiloff and Brjansk is about half the wear, per million tons of gross load, admissible on gentle gradients.

The greatest wear among the foreign rails laid on the Nicolas Railway is one-third to one-fifth the wear, per million tons of gross load, admissible on gentle gradients.

Of the ninety rails 73 per cent show no deformation ; the other 27 per cent show deformations not exceeding 0·05 millimetre per million tons (0·00200 inch per million of English tons) of gross load.

None of the ninety rails has a hardness, measured on the Brinnell system, of less than 175 (248,899 lb. per square inch).

The carbon content is not less than 0·32 and not more than 0·84 per cent.

The figures given in table V lead to the following conclusions :

The greatest loss of weight, of the better rails (in use twenty-four to thirty years), does not exceed 9·5 kilograms (20·94 lb.), or 1·09 kilograms per metre (2·20 lb. per yard) of rail, for a

Table V.

Index number.	Rail number.	Location: at kilometre.	MANUFACTURER.	Weight, kilograms per metre (lb. per yard).	Length, metres.	Weight of rail before laying, kilograms (lb.).	PARTICULARS OF USE.	Time in use, years.
1	8	205	Demidoff	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1891. Line straight and level. Taken out in May 1904 to put in a stronger cross-section (43 kilograms per metre [86·68 lb. per yard]). Wear regular. No traces of crushing.	13
2	13	205	—	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)		13
3	16	205	—	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)		13
4	43	205	Brjansk	32·4 (65·31)	10·85 (35′ 7″)	351·18 (774·22)	Laid in 1899. Line straight. Gradient 3 per mil. Taken out in May 1904 to put in a stronger cross-section (43 kilograms per metre [86·68 lb. per yard]). Wear regular. No traces of crushing.	5
5	48	457	Putiloff	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1888. Line straight and level. See No. 1.	16
6	132	308	—	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1880. Line straight. Gradient 2 per mil. See No. 1.	24
7	75	464	New Russia	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1889. Line straight. Gradient 4·5 per mil. See No. 1.	15
8	76	464	—	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1889. Line straight. Gradient 4·5 per mil. Taken out in May 1904 to put in a stronger cross-section (43 kilograms per metre [86·68 lb. per yard]). No traces of crushing. Wear uniform.	15
9	18	354	Wilson & Cammell	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1875. Line straight. Gradient 1 per mil. Taken out for the same reason as No. 8. No traces of crushing. Wear uniform.	29
10	19	354	— —	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)		29
11	20	354	— —	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)		29
12	21	354	— —	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)		29
13	35	352	— —	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1874. Line straight. Gradient 1·5 per mil. See No. 9.	30
14	55	217	— —	32·17 (64·85)	8·68 (28′ 5 3/4″)	278·46 (613·90)	Laid in 1875. Line straight. Gradient 2·5 per mil. See No 9.	29
15	57	217	— —	32·17 (64·85)	8·68 (28′ 5 3/4″)	278·46 (613·90)		29
16	58	217	— —	32·17 (64·85)	8·68 (28′ 5 3/4″)	278·46 (613·90)		29
17	101	75	Charles Cammell	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1879. Line straight. Gradient 2·5 per mil. See No. 1.	25
18	123	302	— —	32·17 (64·85)	8·68 (28′ 5 3/4″)	278·46 (613·90)	Laid in 1874. Line straight. Gradient 3 per mil. See No. 1.	30
19	23	354	Brown, Bayley and Dixon	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1875. Line straight. Gradient 1 per mil. See No. 1.	29
20	24	354	— — —	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)		29
21	28	351	— — —	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1876. Line straight. Gradient 2 per mil. See No. 1.	28
22	89	75	Creusot, Schneider	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)	Laid in 1875. Line straight. Gradient 3·5 per mil. See No. 1.	29
23	90	75	— —	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)		29
24	93	75	— —	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)		29
25	94	75	— —	32·4 (65·31)	8·68 (28′ 5 3/4″)	281·23 (620·01)		29

Table V.

Total load, millions of tons (millions of English tons).	Weight of rail when taken out, kilograms (lb.).	Loss of weight, per cent.	Ultimate tensile stress, R, kilograms per square millimetre (lb. per square inch).	Limit of elasticity, R', kilograms per square millimetre (lb. per square inch).	Ratio $\alpha = \frac{R'}{R}$.	Carbone content, per cent.	HARDNESS ACCORDING TO BRINELL, kilograms per square millimetre (lb. per square inch).				MAXIMUM WEAR, millimetres (inches)			
							Upper part of head.	Lower part of head.	Web.	Flange.	in height.	laterally.	per million tons (per million English tons) of load	
													in height.	lat- erally.
80·11 (78·84)	280·09 (617·49)	0·4	59·9 (85,195)	31·2 (44,375)	0·52	0·42	175 (248,899)	167 (237,521)	160 (227,565)	160 (227,565)	1 (0·039)	0·75 (0·030)	0·013 (0·00052)	0·009 (0·00036)
80·11 (78·84)	278·46 (613·90)	0·9	67·4 (95,862)	36·5 (51,913)	0·54	0·44	224 (318,591)	207 (294,412)	188 (267,389)	179 (254,588)	0·75 (0·030)	0·75 (0·030)	0·009 (0·00036)	0·009 (0·00036)
80·11 (78·84)	276·82 (610·28)	1·5	58·3 (82,919)	33·69 (47,917)	0·58	0·45	179 (254,588)	175 (248,899)	167 (237,521)	163 (231,832)	0·75 (0·030)	0·75 (0·030)	0·009 (0·00036)	0·009 (0·00036)
33·54 (33·01)	346·11 (763·04)	1·4	66 6 (94,724)	39·8 (56,607)	0·60	0·58	229 (325,703)	207 (294,412)	207 (294,412)	212 (301,524)	0·25 (0·010)	1·5 (0·059)	0·007 (0·00028)	0·045 (0·00180)
52·56 (51·73)	278·95 (614·98)	0·8	80·0 (113,783)	43·0 (61,158)	0·54	0·49	242 (344,192)	248 (352,726)	229 (325,703)	235 (334,236)	0·125 (0·005)	1 (0·039)	0·002 (0·00008)	0·019 (0·00076)
79·80 (78·54)	279·42 (616·02)	3·4	60·54 (86,105)	30·59 (43,508)	0·51	0·53	197 (280,190)	179 (254,588)	153 (217,609)	188 (267,389)	1·5 (0·059)	1·5 (0·059)	0·019 (0·00076)	0·019 (0·00076)
50·78 (49·98)	271·91 (599·46)	3·3	84·13 (119,657)	45·54 (64,771)	0·54	0·56	255 (362,682)	270 (384,016)	248 (352,726)	255 (362,682)	0·75 (0·030)	0·75 (0·030)	0·015 (0·00060)	0·015 (0·00060)
50·78 (49·98)	274·69 (605·59)	2·3	72·7 (103,400)	36·8 (52,340)	0·51	0·77	229 (325,703)	229 (325,703)	218 (310,057)	218 (310,057)	1 (0·039)	1 (0·039)	0·02 (0·00080)	0·02 (0·00080)
34·90 (34·35)	272·3 (600·32)	3·1	70·09 (99,688)	39·02 (55,497)	0·55	0·50	213 (302,946)	218 (310,057)	207 (294,412)	229 (325,703)	2 (0·079)	0·75 (0·030)	0·057 (0·00228)	0·021 (0·00084)
34·90 (34·35)	276·82 (610·28)	1·5	73·3 (104,253)	37·4 (53,193)	0·51	0·52	224 (318,591)	218 (310,057)	212 (301,524)	224 (318,591)	2·5 (0·098)	1·5 (0·059)	0·071 (0·00284)	0·042 (0·00168)
34·90 (34·35)	276·49 (609·56)	1·6	...	...	...	0·77	197 (280,190)	188 (267,389)	179 (254,588)	188 (267,389)	2·25 (0·089)	1·25 (0·050)	0·064 (0·00256)	0·036 (0·00144)
34·90 (34·35)	276·82 (610·28)	1·5	64·6 (91,879)	31·80 (45,229)	0·49	0·47	207 (294,412)	197 (280,190)	179 (254,588)	207 (294,412)	1·25 (0·050)	1 (0·039)	0·036 (0·00144)	0·028 (0·00112)
35·70 (35·14)	271·91 (599·46)	3·3	...	...	...	0·52	197 (280,190)	197 (280,190)	188 (267,389)	197 (280,190)	1·25 (0·050)	0·75 (0·030)	0·035 (0·00140)	0·021 (0·00084)
161·17 (158·62)	276·00 (608·48)	0·9	74·1 (105,391)	48·4 (68,838)	0·65	0·84	277 (393,972)	294 (418,151)	285 (405,350)	285 (405,350)	1 (0·039)	1 (0·039)	0·006 (0·00024)	0·006 (0·00024)
161·17 (158·62)	276·82 (610·28)	0·6	47·44 (67,473)	39·31 (55,910)	0·82	0·63	212 (301,524)	207 (294,412)	197 (280,190)	207 (294,412)	1·25 (0·050)	1·25 (0·050)	0·007 (0·00028)	0·007 (0·00028)
161·17 (158·62)	276·82 (610·28)	0·6	63·7 (90,599)	32·7 (46,509)	0·51	0·30	175 (248,899)	175 (248,899)	183 (260,278)	197 (280,190)	1·75 (0·069)	0·25 (0·010)	0·01 (0·00040)	0·0015 (0·00006)
36·87 (36·29)	271·91 (599·46)	3·3	46·39 (65,980)	33·54 (47,703)	0·72	0·58	179 (254,588)	197 (280,190)	171 (243,210)	165 (234,677)	1·75 (0·069)	1·25 (0·050)	0·047 (0·00188)	0·034 (0·00136)
91·05 (89·61)	274·69 (605·59)	1·3	64·99 (92,434)	32·16 (45,741)	0·50	0·55	218 (310,057)	202 (287,301)	197 (280,190)	197 (280,190)	1 (0·039)	1·75 (0·069)	0·011 (0·00044)	0·019 (0·00076)
34·90 (34·35)	273·54 (603·05)	2·7	63·7 (90,599)	36·4 (51,771)	0·57	0·51	188 (267,389)	188 (267,389)	171 (243,210)	197 (280,190)	1·75 (0·069)	1·75 (0·069)	0·05 (0·00200)	0·05 (0·00200)
34·90 (34·35)	276·00 (608·48)	1·8	71·9 (102,262)	38·3 (54,473)	0·52	0·51	218 (310,057)	212 (301,524)	229 (325,703)	197 (280,190)	2·75 (0·108)	2 (0·079)	0·08 (0·00320)	0·05 (0·00200)
34·09 (33·55)	279·28 (615·71)	0·6	...	...	...	0·49	192 (273,078)	197 (280,190)	207 (294,412)	179 (254,588)	2 (0·079)	1 (0·039)	0·058 (0·00232)	0·029 (0·00116)
40·48 (39·84)	276·82 (610·28)	1·5	67·39 (95,848)	42·83 (60,916)	0·63	0·38	207 (294,412)	207 (294,412)	207 (294,412)	183 (260,278)	1·5 (0·059)	1·5 (0·059)	0·03 (0·00120)	0·03 (0·00120)
40·48 (39·84)	275·68 (607·77)	1·9	66·4 (94,440)	40·00 (56,891)	0·60	0·55	212 (301,524)	202 (287,301)	192 (273,078)	197 (280,190)	1·75 (0·069)	1·5 (0·059)	0·04 (0·00160)	0·03 (0·00120)
40·48 (39·84)	274·86 (605·96)	2·2	66·3 (94,297)	38·1 (54,189)	0·57	0·48	202 (287,301)	202 (287,301)	202 (287,301)	188 (267,389)	1·5 (0·059)	0·75 (0·030)	0·03 (0·00120)	0·019 (0·00076)
40·48 (39·84)	276·49 (609·56)	1·6	68·06 (96,801)	35·1 (49,922)	0·52	0·49	224 (318,591)	207 (294,412)	156 (221,876)	197 (280,190)	1·5 (0·059)	1·25 (0·050)	0·03 (0·00120)	0·031 (0·00124)

total load of 79 million tons (77·8 million English tons) (No. 6/132); the smallest (rails in use same time) is 2·46 kilograms (5·42 lb.), or 0·28 kilogram per metre (0·56 lb. per yard) of rail, for a total load of 161 million tons (158·5 million English tons).

The greatest loss of weight (rails thirteen to twenty-four years in use) does not exceed 9·02 kilograms (19·89 lb.), or 1·03 kilograms per metre (2·08 lb. per yard) of rail (No. 7/75); the smallest loss (rails in use same time) is 0·82 kilogram (1·81 lb.), or 0·094 kilogram per metre (0·189 lb. per yard) of rail, for a total load of 80 million tons (78·7 million English tons) (No. 1/8).

The smallest hardness, measured on the Brinnell system, is 175 (248,899 lb. per square inch).

The smallest wear, vertically, namely 0·002 to 0·007 millimetre per million tons (0·00008 to 0·00028 inch per million English tons) of total load, is shown by rails having a hardness of not less than 212 (301,524 lb. per square inch) (Nos. 4/43, 5/48, 14/55, 15/57).

The smallest wear on the side, namely 0·006 to 0·009 millimetre per million tons (0·00024 to 0·00036 inch per million English tons) of total load, is shown by rails having a hardness of not less than 179 (254,588 lb. per square inch) (Nos. 2/13, 3/16, 14/55, 15/57).

The smallest uniform wear, namely 0·006 millimetre per million tons (0·00024 inch per million English tons) of total load, is shown by rail No. 14/55, which is very hard, and that all over its cross-sections (277 to 294 [393,970 to 418,150 lb. per square inch]). This rail shows also the least loss of weight for twenty-nine years of use and a total load of 161 million tons (158·5 million English tons).

The ratio $\alpha = \frac{R}{R'}$ varies between 0·50 and 0·82 and is thus very high.

This ratio is 0·82 for the best rail (No. 14/55); this is exceptionally high.

Figure 3 shows the difference between the hardness 197 (280,190 lb. per square inch) of the more recent rails on the Nicolas Railway, weighing 43 kilograms per metre (86·68 lb. per yard), and the hardness 294 (418,150 lb. per square inch) of the rail 14/55, weighing 32·17 kilograms per metre (64·85 lb. per yard), which was supplied by Messrs. Wilson and Cammell. Figures 4 and 5 show the grain of these two rails; it is radically different. Figure 6 shows the grain of the steel of rails Nos. 28/89 and 17/101 of table V.

VIII. — **Chemical composition and mechanical properties of steel for rails of good quality.**

The best rails of tables II and V are :

a) Demidoff	No. 57/171,	Technical Association,
b) —	No. 2/13,	Nicolas Railway,
c) —	No. 3/16,	— —
d) Brjansk	No. 4/43,	— —
e) Putiloff	No. 5/48,	— —
f) Wilson & Cammell	No. 14/55,	— —
g) —	No. 15/57,	— —

They show that rails may be expected to give satisfactory results if they satisfy the following conditions : carbon content not less than 0·45 per cent, hardness B not less than 200 (284,456 lb. per square inch), ratio $\alpha = \frac{R'}{R}$ not less than 0·50.

The rest depends on the method of manufacture of the steel and on its treatment; particularly on the temperature at which the rails are rolled.

It is certainly true that by careful treatment good rails can be produced having a lower carbon content and lower values for B and α; nevertheless it is advisable to take into account the results mentioned above, particularly as regards a high limit of elasticity. For the figures given show that it is on this latter that the good behaviour and the long life of rails, under all conditions of working, chiefly depends.

[621. 154.5]

HIGH STEAM PRESSURE IN LOCOMOTIVE SERVICE (¹).

A brief abstract of a report submitted to the Carnegie Institute of Washington, August 17, 1906,

By Prof. W. F. M. GOSS.

Fig. 1, p. 441.

(*Railway Age.*)

The Carnegie Institution of Washington, D. C., some three years since, became a patron of Purdue University for the purpose of promoting a research to determine the value of high steam pressures in locomotive service. The work outlined under these auspices has now been completed, and the final report has been rendered to the institution, and will soon be published. Meantime, the institution has given its consent to the publication of a preliminary statement concerning methods and results.

The tests outlined included a series of runs for which the average pressure was respectively, 240, 220, 200, 180, 160, 120 pounds, a range which extends far below and well above pressures now common in locomotive service. The tests of each series were to be sufficiently numerous to define completely the performance of the engine when operated at any speed and for all positions of the reverse lever possible with a wide open throttle. So far as practicable, each test was to be of sufficient duration to permit the efficiency of engines and boiler to be accurately determined, but where this could not be done, cards were to be taken.

The first test was run February 15, 1904, and the last August 7, 1905. A registering counter attached to the locomotives shows that between these dates, the locomotive drivers made 3,113,333 revolutions which is equivalent to 14,072 miles. The completed record includes the data of one hundred different tests.

The locomotive, upon which the tests were made, is that regularly employed in the laboratory of Purdue University where it is known as " Schenectady No. 2. " The characteristics of this locomotive are rather generally known.

Difficulties in operating under high pressures.

The work with the experimental locomotive has shown that those difficulties which in locomotive operation are usually ascribed to bad water, increase rapidly as the pressure is increased.

(¹) Abstract of a paper before the Western Railway Club, Chicago, November 20, 1906.

The water supply of the Purdue laboratory contains a considerable amount of magnesia and carbonate of lime. When used in boilers carrying low pressure, there is no great difficulty in washing out practically all sediment. The boiler of the first experimental locomotive, Schenectady No. 1, which carried but 140 pounds and was run at a pressure of 130 pounds, after serving in the work of the laboratory for a period of six years, left the testing plant with a boiler which was practically clean. Throughout its period of service, this boiler rarely required the attention of a boiler-maker to keep it tight. Water from the same source was ordinarily used in the boiler of Schenectady No. 2 which carried a pressure of 200 pounds or more. It was soon found that this boiler which is of the same general dimensions as that of Schenectady No. 1, operating under the higher pressure, frequently required the attention of a boiler-maker. After having been operated no more than 30,000 miles, cracks developed in the side-sheets, making it impossible to keep the boiler tight, and new side-sheets were applied. In operating under pressures as high as 240 pounds, the temperature of the water delivered by the injector was so high that scale was deposited in the check valve, in the delivery pipe and in the delivery tube of the injector. Under this pressure, with the water normal to the laboratory, the injectors often failed after they had been in action for a period of two hours. The loss of tests through failure of the injector, and through the starting of leaks at stay-bolts, as the tests proceeded, became so annoying that, as a last resort, a new source of water supply was found in the return tank of the university heating plant. This gave practically distilled water, and its use greatly assisted in running the tests at 240 pounds pressure.

Probably some of the difficulties experienced in operating under very high steam pressures, were due to the experimental character of the plant, and would not appear after practice had by gradual process of approach become committed to their use, but the results are clear in their indication that the problem of boiler maintenance, especially in bad water districts, will become more complicated as pressures are further increased. Since, taking the country over, there are few localities where locomotives can be furnished with pure water, the conclusion stated should be accepted as rather far-reaching in its effect

The tests developed no serious difficulties in the lubrication of valves and pistons under pressures as high as 240 pounds, though the lubrication could not be done with a grade of oil previously employed.

With increase of pressure, any incidental leakage either of the boiler or from cylinders becomes more serious in its effect upon performance. In advancing the work of the laboratory, every effort was made to prevent loss from such causes, and results were frequently thrown out and tests repeated because of the development of leaks of steam around piston and valve rods, or of water from the boiler. Notwithstanding the care taken, it was impossible under the higher pressures to prevent all leakage, and the best that can be said for the data under these conditions, is that they represent results which are as free as practical from irregularities arising from the causes referred to, that is, so far as leakage may affect performance, the results of the laboratory tests may safely be accepted as the record of maximum performance.

In concluding this brief review of the difficulties encountered in the operation of locomotives under very high steam pressures, the reader is reminded that an increase of pressure is an embellishment to which each detail in the design of the whole machine must give a proper response. A locomotive which is to operate under such pressure will need to be more carefully designed and more perfectly maintained, than a similar locomotive designed for lower pressure, and much of that which is crude and imperfect, but nevertheless serviceable in the operation of locomotives using a lower pressure, must give way to a more perfect practice in the presence of the higher pressure.

The effect of different pressures upon boiler performance.

1. — The evaporative efficiency of a locomotive boiler is but slightly affected by changes in pressure, between the limits of 120 and 240 pounds.

2. — Changes in steam pressure between the limits of 120 and 240 pounds will produce an effect upon the efficiency of the boiler which will be less than $^1/_2$ pound of water per pound of coal.

3. — The equation $E = 11{\cdot}305 - 0{\cdot}221H$ in which E is the number of pounds evaporated from and at 212° per pound of coal, and H is the pounds of water evaporated per foot of heating surface per hour, represents the evaporative efficiency of the boiler of locomotive Schenectady No. 2 when fired with Youghiogheny coal for all pressures between the limits of 120 and 240 pounds, with an average error for any pressure which does not exceed 2·1 per cent.

4. — It is safe to conclude that changes of no more than 40 or 50 pounds in pressure will produce no measureable effect upon the evaporative efficiency of the modern locomotive boiler.

The effect of different pressures upon smoke-box temperatures.

1. — The smoke-box temperature falls between the limits of 590° Fahr. and 850° Fahr., the lower limit agreeing with a rate of evaporation of 4 pounds per foot of heating surface per hour, and the higher with a rate of evaporation of 14 pounds per foot of heating surface per hour.

2. — The smoke-box temperature is so slightly affected by changes in steam pressure as to make negligible the influence of such changes in pressure for all ordinary ranges.

3. — The equation $T = 488{\cdot}5 + 25{\cdot}66H$ where T is the temperature of the smoke-box and H is the weight of water evaporated from and at 212° per foot of heating surface per hour, possesses a high degree of accuracy for all ordinary pressures.

The engine performance.

The shaded zone in the diagram represents the range of performance as it appears from all tests run under the several pressures employed. It shows that the variation in performance for all conditions of running which are possible with a wide open throttle scarcely exceeds 5 pounds. For purposes of comparison, it is desirable to define the effect of pressure on performance by a line, and to this end an attempt has been made to reduce the zone of performance to a representative line. In preparing to draw such a line, the average performance of all tests at each of the different pressures was obtained and plotted, the results being shown by the circles on the diagram. Points thus obtained may be regarded as fairly representing the performance of the engine under the several pressure only so far as the tests run for each different pressure may be assumed to fairly represent the range of speed and cut-off under which the engine would ordinarily operate. The best results for each different pressure as obtained by averaging the best results for each speed at this pressure, is given upon the diagram in the form of a light cross. These points may be regarded as furnishing a satisfactory basis of comparison, in so far as it may be assumed that when the speed has been determined, an engine in service will always operate under conditions of highest efficiency. Again the left-hand edge of the shaded zone represents a comparison based on maximum performance at whatever speed or cut-off.

In addition to the points already described, there is located upon the diagram a curve showing the performance of a perfect engine with which the plotted points derived from the data of tests may be compared. Guided by this curve representing the performance of a perfect engine, a line AB has been drawn proportional thereto, and so placed as to fairly represent the circular points derived from the experiments. It is proposed to accept this line as representing the steam consumption of the experimental engine under the several pressures employed. It is to be noted that it is not the minimum performance nor the maximum, but it is a close approach to that performance which is suggested by an average of all results derived from all tests which were run. Since its form is based upon a curve of perfect performance, it has a logical basis and since it does no violence to the experimental data, it seems to be justifiable.

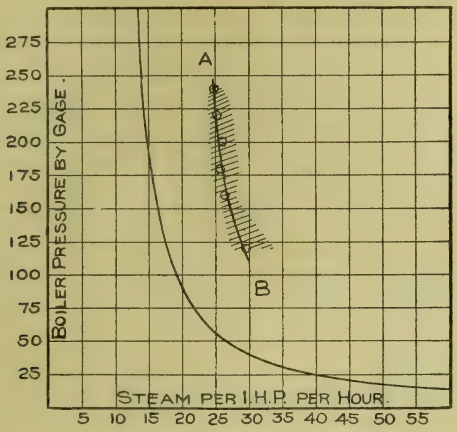


Fig. 1. — Diagram showing economy as affected by boiler pressure.

Coal consumption.

Accepting the curve AB as fairly representing the consumption of steam, the corresponding consumption of Youghiogheny lump coal for the several pressures employed is shown by the following table.

Boiler pressure.	Per I. H. P.	Coal. Saved for each increment of pressure.	
240	3·31 per hour.	...	...
220	3·35 —	0·04 pound.	1·2 per cent.
200	3·40 —	0·05 —	1·5 —
180	3·46 —	0·06 —	1·7 —
160	3·53 —	0·07 —	2·0 —
140	3·67 —	0·14 —	3·8 —
120	3·84 —	0·17 —	4·4 —

The last two columns of the table show the diminishing value of the fuel saving which results from a given increment of pressure as the scale of pressure is ascended. For example, increasing the pressure from 120 to 140 pounds results in a full saving of 4·4 per cent, while a similar increment from 220 to 240 pounds results in a saving of but 1·2 per cent.

Increased boiler capacity as an alternative for higher pressure.

Previous publications from the Purdue laboratory have shown the possibility under certain conditions, of securing a substitute for very high boiler pressures in the adoption of a boiler of larger capacity, the pressure remaining unchanged. If, for example, in designing a new locomotive, it is found possible to allow an increase of weight in the boiler as compared with that of some older type, it becomes a question as to whether this possible increase in weight should be utilized by providing a higher pressure, or for an increase in the extent of heating surface. The results of tests supplemented by facts concerning the weight of boilers designed for different pressures and for different capacities supply the data necessary for an analysis of this question.

Starting with pressures which are comparatively low, the most pronounced benefits are those to be derived from increments of pressure. With each rise in pressure, however, the chance for gain through further increase diminishes. With a starting point as high as 180 pounds, the saving through increased pressure is but slightly greater than that which may result through increased boiler capacity. For still higher pressures, the argument is strongly in favour of increased capacity.

The fact should be emphasized that the conclusions above described are based upon data which lead back to the question of coal consumption. The gains which are referred to are measured in terms of coal which may be saved in the development of a given amount of power. It will be remembered that conditions which permit a saving in coal will, by the sacrifice of such a saving, open the way for the development of greater power, but the question as defined. is one concerning economy in the use of fuel.

Attention should be called to the fact that gains which have been defined as resulting from increase of pressure are to be regarded as the maximum gross; as maximum because they are based upon results derived from a locomotive which was at all times maintained in the highest possible condition, and as gross because on the road conditions are likely to be introduced which will necessitate deductions therefrom.

On the other hand, the relations which has been established showing the gain to be derived through increased boiler capacity is subject to but few qualifiying conditions It rests upon the fact that for the development of a given power, a large boiler will work at a lower rate of evaporation per unit area of heating surface than a smaller one. The saving which results from diminishing the rate of evaporation is sure, whether the boiler is clean or foul, tight or leaky, or whether the feed-water is good or bad, the reduced rate of evaporation will bring its sure return in the form of increased efficiency. An increase in the size of a boiler will involve some increase in the cost of maintenance, but such increase is slight and of a sort which has not been regarded in the discussion involving boilers designed for higher pressure.

Basing comparisons upon an initial pressure of 120 pounds, a 5 per cent increase in weight when utilized in securing a stronger boiler will improve the efficiency 8·5 per cent, while if utilized in securing a larger boiler, the improvement will be a trifle less than 3 per cent. Arguing from this base, the advantage to be derived from an increase of pressure is great.

Basing comparisons upon an initial pressure of 140 pounds, the relative advantage of increasing the pressure diminished though on the basis of a 5 per cent increase in weight, it is still double that to be obtained by increasing the capacity.

Basing comparisons upon an initial pressure of 160 pounds, the advantage to be gained by increasing the pressure over that which may be had by increasing the capacity is very slight.

Basing comparisons upon an initial pressure of 180 pounds, the advantage under ideal conditions of increasing the pressure as compared with that resulting from increasing the capacity, has a maximum value of approximately 1/2 per cent. In view of the incidental losses upon the road, the practical value of the apparent advantage is nil.

Basing comparisons upon an initial pressure of 200 pounds, it appears that under ideal conditions, either the pressure or the capacity may be increased with equal advantage, which in effect is a strong argument in favour of increased capacity rather than of higher pressure.

Basing comparisons upon a pressure of 220 pounds, it appears that even under ideal conditions of maintenance, the gain in efficiency resulting from an increase of pressure is less than that resulting from an increase of capacity. In view of this fact, no possible excuse can be found for increasing pressure above the limit of 220 pounds.

Conclusions.

1. — Tests have been made to determine the performance of a typical locomotive when operating under a variety of conditions with reference to speed, power and steam pressure. The results of 100 such tests have been made of record.

2. — The results apply only to practice involving single expansion locomotives using saturated steam. They cover only such conditions as may be maintained with wide open throttle. Pressures specified are to be accepted as running pressures. They are not necessarily those at which safety valves open.

3. — The steam and coal consumption under normal conditions of running have been established as follows :

Boiler pressure.	Steam per hour.	Coal per H. P. hour.
120 lb.	29·1 lb.	3·84 lb.
140 —	27·7 —	3·67 —
160 —	26·6 —	3·53 —
180 —	26·0 —	3·46 —
200 —	25·5 —	3·40 —
220 —	25·1 —	3·35 —
240 —	24·7 —	3·31 —

4. — The results show that the higher the pressure, the smaller the possible gain resulting from a given increment of pressure. An increase of steam from 160 to 200 pounds results in a saving of 1·1 pounds of steam per horse-power hour, while a similar change from 200 to 240 pounds improves the performance only to the extent of 0·8 of a pound per horse-power hour.

5. — An increase of pressure from 160 to 200 pounds results in a saving of 0·13 pounds of coal per horse-power hour, while a similar change from 200 to 240 results in a saving of but 0·09 pounds.

6. — Under service conditions, the improvement in performance with increase of pressure will depend upon the degree of perfection attending the maintenance of the locomotive. The values quoted in the preceding paragraphs assume a high order of maintenance. If this is lacking, it may easily happen that the saving which is anticipated through the adoption of higher pressures will entirely disappear.

7. — The difficulties to be met in the maintenance both of boiler and cylinders increase with increase of pressure.

8. — The results supply an accurate measure by which to determine the advantage of increas-

ing the capacity of a boiler. For the development of a given power, any increase in boiler capacity brings its return in improved performance without adding to the cost of maintenance, or opening any new avenues for incidental losses. As a means of improvement, it is more certain than that which is offered by increase of pressure.

9. — As the scale of pressure is ascended, an opportunity to further increase the weight of a locomotive should, in many cases, find expression in the design of a boiler of increased capacity rather than in one for higher pressures.

10. — Assuming 180 pounds pressure to have been accepted as standard, and assuming the maintenance to be of the highest order, it will be found good practice to utilize any allowable increase in weight by providing a larger rather than by providing a stronger boiler to permit higher pressures.

11. — Wherever the maintenance is not of the highest order, the standard running pressures should be below 180 pounds.

12. — Wherever the water which must be used in boilers contains foaming or scale-making admixtures, best results are likely to be secured by fixing the pressure below the limit of 180 pounds.

13. — A simple locomotive using saturated steam, will render good and efficient service when the running pressure is as low as 160 pounds; under most favourable conditions, no argument is to be found in the economical performance of a machine which can justify the use of pressures greater than 200 pounds.

[625 .253]

THE CHAPSAL-SAILLOT COMPRESSED-AIR BRAKE.

Figs. 1 to 9, pp. 447 and 448.

(*Engineering.*)

The great development that has taken place in passenger and goods traffic has led to repeated increases in the number, weight, and speed of trains; hence the more powerful types of locomotives and the larger capacity of the rolling-stock now in service. On the main lines of the French railways, for example, there are at the present time goods trains partially braked at the forward end by the continuous brake, of a weight exceeding 700 tons, running at a speed of 60 kilometres (37·5 miles); also heavy passenger trains, weighing up to 300 tons, and travelling at a speed of 120 kilometres (75 miles) at certain parts of their journeys. Owing to the increase in traffic and speed, attention has been called to several of the most essential rolling-stock fittings; and among these, the brake may be placed in the front rank. In its essential features, the continuous brake now fitted is identical with the one put in service about twenty years ago. It has, however, been improved from time to time in matters of detail, and attempts have repeatedly been made, both in Europe and in the United States, with a view to secure a uniform braking effect per ton of load and regular graduation in the braking power.

In order not to completely skid the wheels of empty vehicles, it has been considered desirable that the maximum pressure on the brakes of a goods train should be regulated for each type of vehicle on the weight of that vehicle empty, this leading necessarily to a considerable limitation in the power of the brakes in trains consisting of rolling-stock variably loaded. In the case of the newer goods and mineral wagons which have recently been put in service on the French railways, the weight, when fully loaded, is occasionally more than four times the weight of the vehicle empty. In some countries — The United States, for instance — the difference between the weight empty and the weight loaded is equally marked. The distance required for stopping with the brakes now used is thus too great, notwithstanding the rapidity with which they may be applied. The retarding effect per ton on empty and loaded vehicles, varies in large proportions (1 to 0·25); the stopping length for empty and loaded vehicles running free, would be inversely proportional to the retarding effect, and these conditions in trains result in unequal strains on the couplings. Further inequality in the braking action is due to difference of pressure in the brake cylinders, resulting from variations in the travel of the pistons from unequal wear in the shoes.

In order, therefore, to secure the maximum degree of safety, now that high-capacity rolling-stock is being used more extensively, there are advantages in the use of a brake in which the braking action is independent of the wear of the shoes, and constantly adjustable to the load carried by each separate vehicle forming a train.

The advantages stated above are claimed to have been fully met by the Chapsal-Saillot brake, illustrated in figures 1 to 9, a specimen of which was to be seen at the Milan Exhibition. Figure 1 shows the method of fixing the brake and its mechanism underneath the frame of a vehicle. The brake proper is illustrated in figure 2, in which A is the brake reservoir, B the regulating reservoir, and C the brake cylinder; this is fitted to each vehicle. The distributor, also shown in figure 2, works by the difference of pressure in the regulating reservoir and in the train-pipe, and ensures the simultaneous filling of both reservoirs when the train is running; when braking, it regulates the supply and the emptying, either gradual or complete, of the brake cylinder. A set of small rods connects the mechanical part of the distributor to the suspension springs, in such a way that the pressure let into the brake cylinder varies for a given difference of pressure in the train-pipe, within large limits, with the loads on the vehicle. The regulating reservoir governs the action of the distributor, and ensures uniformity in the braking along the whole train. The sole duty of the brake reservoir is to supply the brake cylinder.

The distributor is shown in the running position in figure 3. The air from the train-pipe arrives at A, raises the piston B, and fills both reservoirs by flowing through the slits a and b, the holes c, and the valve d, thence through e and f (*see* figure 4). The three diaphragm chambers G, H, I communicate with the atmosphere through the slide-valve J, and the passages g, h, i, and k. The brakes is then off.

A reduction of pressure in the train-pipe, causes the piston B to move downwards, the slide J uncovers the port h, the air from the regulating reservoir enters the chamber H, the chamber G communicate through g and g^1 with the pipe A, and the chamber I is closed to the atmosphere. (*See* also figs. 5 and 6.) The difference in pressure in H and G reacts on the diaphragms M and M^1 and causes the lever P to turn rounds its fulcrum; the rod T raises the valve R, and the brake reservoir supplies compressed air to the chamber I. This air drives forward the piston U, which draws with in the fork V and the fulcrum of the lever (fig. 7), the travel being limited by the small rods, already referred to, according to the deflection of the springs of the vehicle. The relative length of the two arms of the lever P is regulated automatically, according to the weight on the axles. The valve R closes when the pressure acting underneath the diaphragm N balances the depression produced at G.

If m be the length of the right arm of the lever, and n that of the left arm, d the reduction of pressure in the train-pipe, therefore the difference in pressure between G and H, f the balancing pressure in I, then, the area of the diaphragms being equal, one obtains the formula

$$f = \frac{m}{n} \times d.$$

The relation between the volume of the reservoirs and the brake cylinder does not affect matters, and f is always proportional to d, whatever be the wear of the brake-shoes. The relation $\frac{m}{n}$ varies with the position of the centre O, and this depends upon

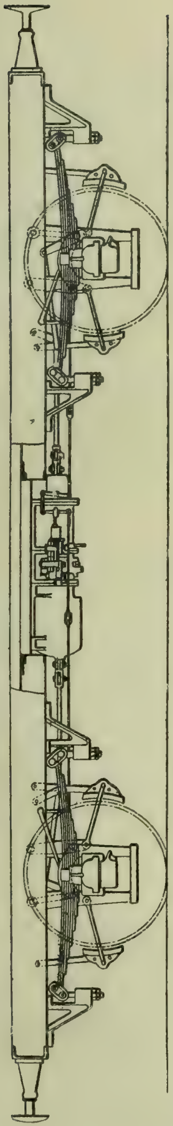


Fig. 1.

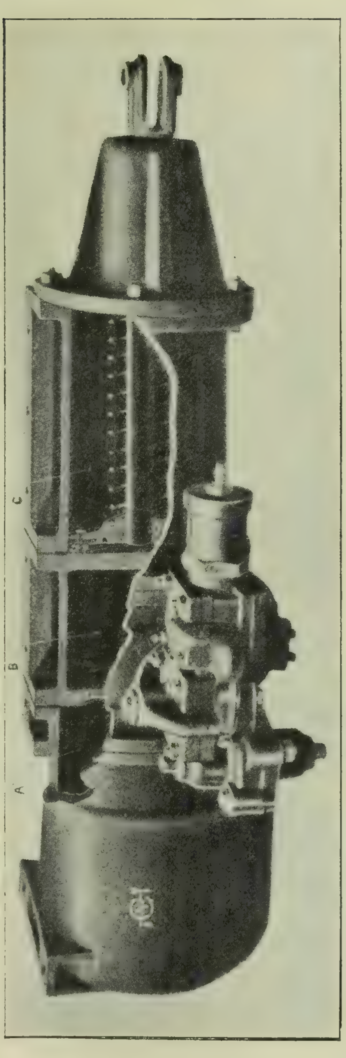
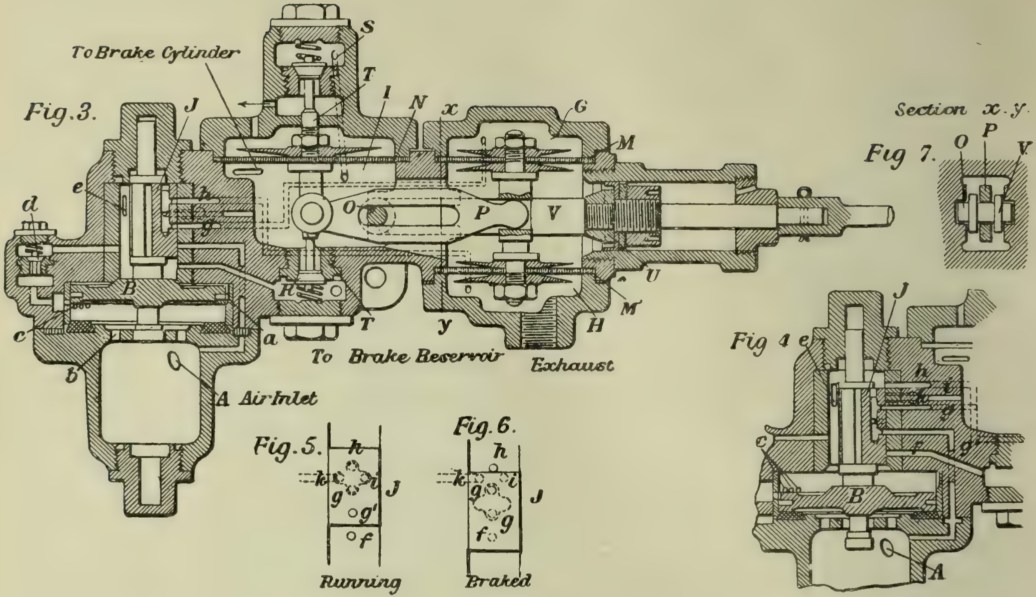


Fig. 2.



Figs. 3 to 7.

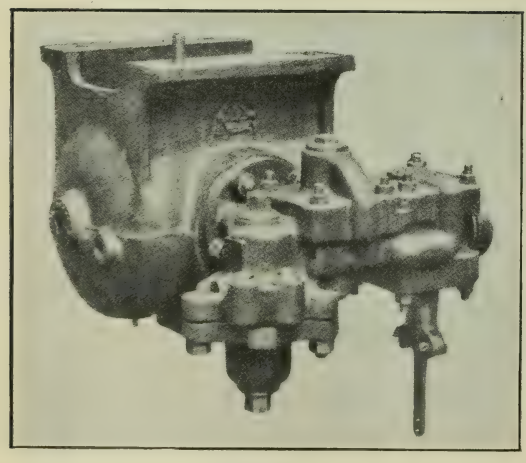


Fig. 8.

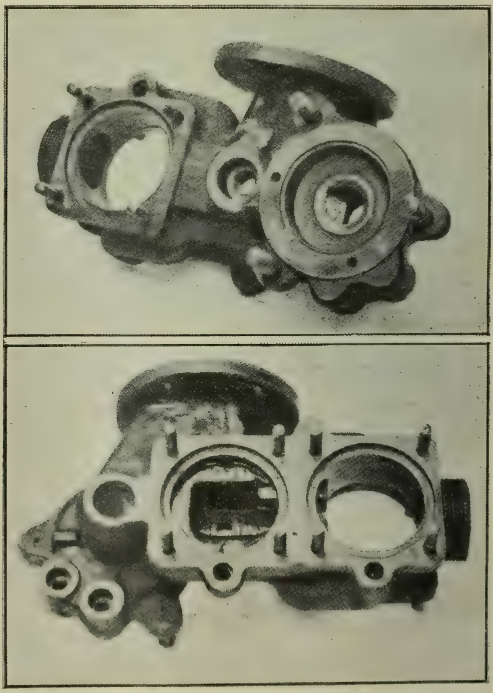


Fig. 9.

the load on the axles, and its maximum, which corresponds with the maximum load, on which is based the area of the brake piston, is determined by the formula

$$P = \frac{m}{n} \times d,$$

where P is the pressure resulting from the complete expansion of the air from the brake reservoir in the brake cylinder, and d the reduction of pressure in the train-pipe corresponding to the putting of the brakes full on.

For lesser loads, corresponding to m^1 and n^1 for the lengths of the lever arms, the formula would be

$$f^1 = \frac{m^1}{n^1} \times d,$$

whence

$$\frac{f}{f^1} = \frac{\frac{m}{n}}{\frac{m^1}{n^1}}, \text{ and } \frac{m^1}{n^1} \text{ is determined } \frac{\frac{m}{n}}{\frac{m^1}{n^1}} = \frac{\text{Weight of vehicle loaded}}{\text{Weight of vehicle empty}},$$

this resulting in a braking effect proportional to the load. The right values for

$$\frac{m}{n} \text{ and } \frac{m^1}{n^1}$$

are obtained for each type of vehicle by means of adjustment in the series of small connecting-rods.

If compressed air be supplied through the pipe, the equilibrium is destroyed in I, the diaphragms act inversely, the valve S is raised and allows the evacuation of the air from the brake cylinder until proportionality in the pressure is attained. The brake can be put off gradually by successive admissions of air. The brakes are full off when the initial pressure is re-established in the compressed-air pipe, when the various parts take up afresh the position shown in figure 3.

When the Chapsal-Saillot brake is fitted to a carriage, the load on which does not vary to any great extent, the parts which ensure proportionality between the braking and the load may be left out. These are the fork V (figs. 3 and 7), the piston U, and its cylinder (fig. 3). The latter is replaced by a screwed plug.

Figure 8 shows a regulating reservoir combined with a distributor with fixed regulation for a carriage, the load on which is not liable to vary within great limits; this is designed for fitting to an existing brake device of another type, and causing it to act on the Chapsal-Saillot principle. Figure 9 illustrates a casting of the distributor.

Messrs. Chapsal and Saillot are engineers to the Western of France Railway Company, and their compressed-air brake is fitted to a series of carriages for the Paris suburban service; it as also being fitted to a number of wagons for express goods service. These brakes have been built in the Paris works of the French Thomson-Houston Company for the *Société générale des freins Lipkowski*, who are the concessionnaires of the patents. The inventors are at the present time also completing a brake of their system to work on the vacuum principle.

[625 .61 (09.4 (.54)]

THE BARSI LIGHT RAILWAY,

Figs. 1 to 6, pp. 451 and 452.

(*Railway Times.*)

An excellent example of the utility of light railway construction is furnished by the lines of the Barsi Light Railway Company. Mr. E. R. Calthrop, M. Inst. C. E., M. I. Mech. E., who has had a unique experience with undertakings of this kind, and whose notable successes include the Leek and Manifold Light Railway, was responsible for the construction of the line, which from its very commencement has yielded substantial profits to the proprietors. As was shown by the annual statement published in the 15th of December last's issue of *The Railway Times*, the directors were able to declare for the year ended June 30, 1906, a dividend of 6 per cent, together with a bonus of 2 per cent. For the last six years the dividends declared have been of a very satisfactory character, as is shown by the following figures : 1901, 5 per cent; 1902, 5 per cent; 1903, 4 per cent; 1904, 5 1/2 per cent; 1905, 6 per cent. For the year ended June 30, 1906, profits were earned equal to 7·35 percent.

At the request of the board Mr. Calthrop, who has been retained as consulting engineer to the company, visited India last cold weather, and spent some months in thoroughly inspecting and reporting on the existing line and extensions (then under construction) and on the proposed further extensions to Latur and Miraj. On the 1st inst. the Pandharpur extension of 31 miles was opened, and Mr. Calthrop made this the occasion for the issue of an interesting souvenir dealing with the history and progress of the Barsi Light Railway undertaking and illustrated by a number of photographs, some of which are reproduced in this issue.

The inception of the Barsi Light Railway, which was the first railway in the Bombay Presidency to be constructed by unassisted private enterprise, dates from the failure in 1886 of a protracted series of negotiations between Government and the Great Indian Peninsula Railway for its construction on the standard gauge (5 ft 6 in.) consequent upon the final intimation of the Secretary of State for India that he was " not disposed to enlarge the operations of that company under any arrangement which would involve any extension of the guarantee of interest or of the grant of pecuniary assistance to the company from the State in any shape. " In the following year, Mr. E. R Calthrop applied to the Government of Bombay for permission to construct the line to Barsi as a 2 ft. 6 in. gauge light railway, on the side of the existing road, as a private enterprise without financial assistance from Government, and although the quest was pursued continuously and with energy upon the part of the promoter, it was not until 1895 that the

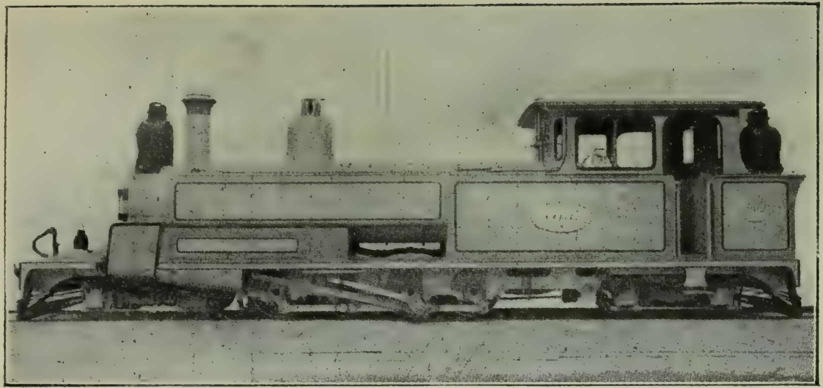


Fig. 1. — Eight-coupled engine with fore and aft bogies.

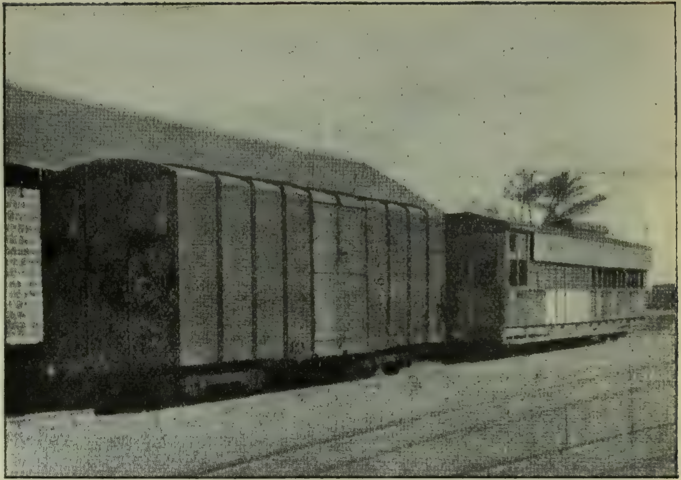


Fig. 2. — Covered wagon. — Tare, 6 tons 6 cwt.; load, 13 tons 14 cwt.

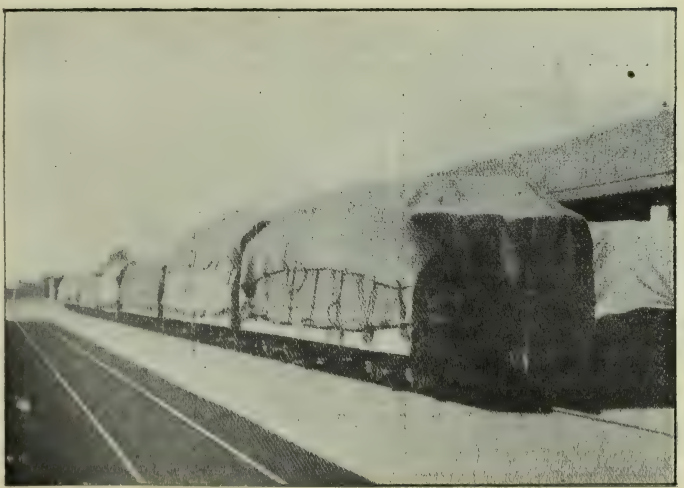


Fig. 3. — Low-sided wagons loaded to full capacity.

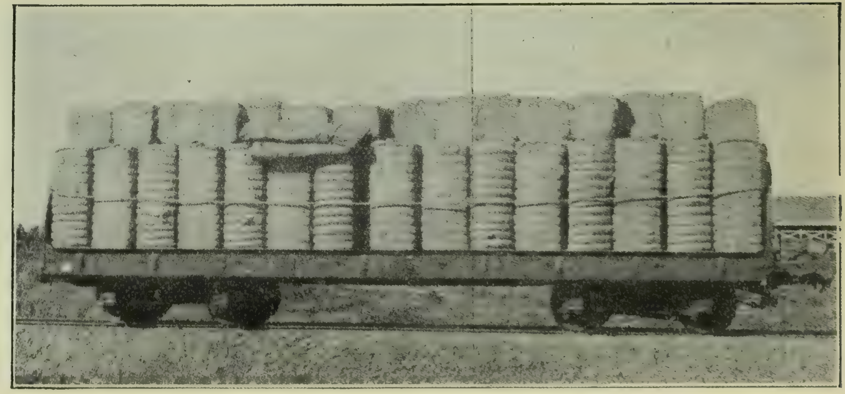


Fig. 4. — Low-sided wagon. — Tare, 4 tons 2 cwt.; load, 15 tons 18 cwt.

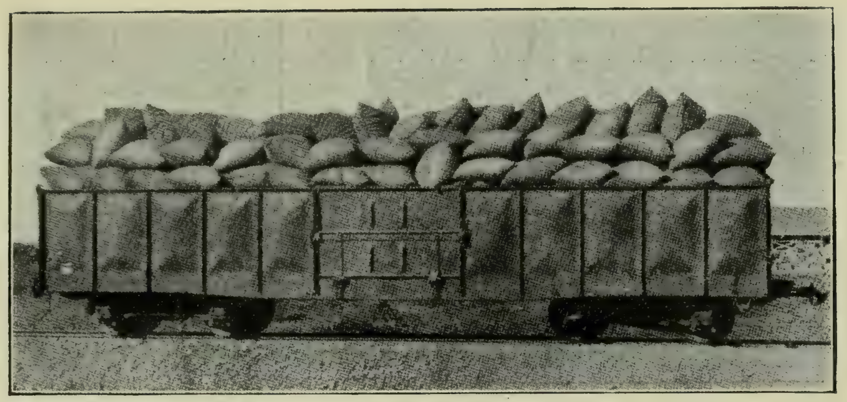


Fig. 5. — High-sided wagon. — Tare, 5 tons 7 cwt.; load, 14 tons 13 cwt.

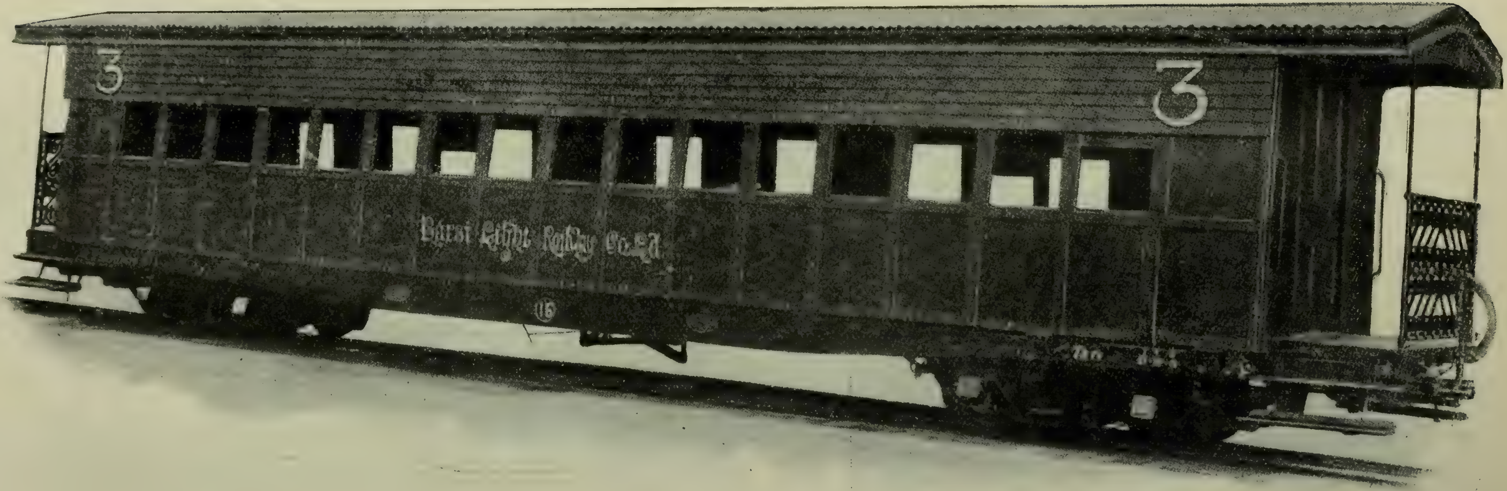


Fig. 6. — Type of pilgrim coach on the Barsi Light Railway.

negotiations were concluded by the signing of the contract between the Secretary of State and the Barsi Light Railway Company. This was followed immediately by the issue of £75,000 ordinary share capital, and the commencement of work in India on January 1, 1896.

Opened by Sir Alexander Wilson, the chairman of the company, on March 18, 1897, the railway, in spite of the fact that it has had to support an independent administration on the very short length of 21 1/2 miles, has been from the first remarkably successful, as is shown by the figures enumerated above. In 1904, the Secretary of State for India having extended the date for the first exercise of his option to purchase the undertaking from January 1, 1924, to January 1, 1944, the Tadwalla extension of 26 1/2 miles was commenced on September 6 of the same year, the issue of £85,000 ordinary share capital being made in the following January. This extension has been completed at a cost considerably within the estimates, and was opened for traffic on May 1 last. In May, 1905, there was an issue of £140,000 debenture stock for the construction of the Pandharpur extension, which was commenced on the 25th of that month and opened for traffic three weeks ago. An application has been made for the further extension of this line from Pandharpur to Miraj, a distance of about 84 miles, which is still under the consideration of Government. Negotiations have also been re-opened for an extension of 36 miles from Tadwalla to Latur, an important trade centre in the territory of H. H. the Nizam of Hyderabad from which the large traffic carried over the existing line originates.

Complete designs for the rolling stock were prepared by Mr. Calthrop three times between 1887 and 1896, each succeeding set of designs improving upon the individual capacity of the rolling stock and the haulage power of the locomotives and total train load, the object being to arrive at a type of railway which would, if possible, retain the carrying capacity of the rolling stock of a standard gauge railway, but at the same time be able to secure all the advantages in lessened cost of construction derivable from the adoption of narrow gauge as regards track.

The Barsi Light Railway is the pioneer exemplar of this gradually developed system of narrow gauge light railways of heavy traffic capacity, and the attempt to achieve a much greater traffic capacity than had previously been attained on the gauge of 2 ft. 6 in. involved many novelties and departures from previous practice in the design of the rolling stock. The chief innovation has been the introduction of the principle of uniformity of axle-load on locomotives, wagons and carriages alike, all of which have been designed to utilise fully, but not to exceed, a uniform maximum axle-load of 5 tons. The principal advantage of the system is the ability to carry upon this narrow gauge goods of any weight and bulk transportable on the Indian standard gauge of 5 ft. 6 in., and to such an extent has this — the principal aim — been realised, that it requires one and a-half broad gauge wagons to take the ordinary load of one Barsi narrow gauge wagon; and the hauling capacity of the Barsi locomotives is sufficient, notwithstanding the restriction of axle-load to 5 tons, to carry, train for train, the same loads of goods and passengers, on rails 35 lb. per yard, as the standard gauge Great Indian Peninsula Railway ordinarily carries over equal gradients, on rails nearly three times the weight.

The permanent way, including the sleepers, is entirely of steel, the design having been carefully thought out in detail, with the object of attaining the lightest weight of rail compatible with great longevity under the stress of a heavy traffic. The maximum axle-load having been fixed at 5 tons, rails of 35 lb., of a specially designed section, were selected, with the object of giving a very large margin of strength. The results given by the combination have been eminently satisfactory, for the rails, fastenings, and sleepers, after ten years' hard use, exhibit no trace of wear or deterioration, and weigh the same weight per yard as when rolled, the mill marks being still unobliterated upon the running surface, showing that the powerful locomotives restricted to a

5-ton axle load, and the heavy train-loads taken by them, have had no destructive effect whatever upon the track. One point of interest in connection with the steel sleepers may be mentioned — namely, that corrugation of the rail-clips was employed for the first time in this design. This improvement has since been adopted, not only by other Indian railways, but universally by all railways employing stamped steel sleepers.

The steepest gradients on the original railway are 1 in 88 to 1 in 90, of which there are several about half-a-mile in length, the remainder being 1 in 100 or over. The sharpest curves on open line are 450 feet radius, and on the Tadwalla-Ghat section 425 feet radius, combined with a gradient of 1 in 50. In sidings curves of 325 feet are employed. The train load ordinarily taken by one of the older locomotives between Barsi Town and Barsi Road Station is 250 to 260 tons. Most of the trains are "mixed" — *i. e.*, goods and passenger — and consist of eighteen vehicles, the usual proportion being fourteen wagons and four carriages. These loads are taken by the engine up the heavy gradients of the line with plenty of reserve power in hand. They can take much heavier loads, but it is always economical to work an engine well within its maximum power. The new engines have greater boiler power and can take 275 tons in everyday working over the same gradients with an equal margin of power. The original engines are 29 ft. 6 in. long over buffers, and weigh 29 tons 8 cwt. in working order and fully loaded. They are of the Consolidation type, having eight wheels coupled of 2 ft. 6 in. diameter, and are provided with a four-wheeled swing link bogie truck at the trailing end. The cylinders are 13 inches diameter by 18 inches stroke. The working pressure is 150 lb. The new engines are 34 ft. 6 in. long over buffers, and weigh 36 tons 5 cwt. in working order. They have eight coupled wheels, but have swing link bogie trucks at each end and are capable of running with equal facility in either direction. A test train run on March 28 last with a gross train load of 310 $^1/_2$ tons was drawn without special effort and to the usual running time by one of the new engines. The total length of this train was 659 $^1/_2$ ft., or, say, 220 yards, and it is interesting to note that this train earned Rs. 433.9 a. op. in running the 21 $^1/_2$ miles.

In designing the wagon stock, the indispensable conditions were that the wagons should be capable of carrying goods of any weight or bulk transportable on a railway of standard gauge; that they should be of the lightest possible tare weight compatible with a proper margin of strength and low cost of maintenance. The wagon stock is of the bogie type and was designed with the following tare weights: lowside, 4 tons 2 cwt.; highside, 5 tons 7 cwt.; and covered, 5 tons 18 cwt. Loaded to the 5-ton axle limit they carry paying loads of 15 tons 18 cwt., 14 tons 13 cwt., and 14 tons 2 cwt. respectively. All the wagons have the same length and width — *viz.*, 25 feet long over headstocks and 6 ft. 7 in. wide inside, equal to 164 square feet floor space. The roofs of the new covered wagons have been carried up to the limit of the loading gauge, and have a tare weight of 6 tons 6 cwt., are capable of carrying six horses or eight ponies under military service conditions, and have a capacity of 1,150 cubic feet. The bulk capacity of lowside and highside wagons fully loaded with bags of wheat and linseed or bales of cotton is about 900 cubic feet. No article, however heavy or bulky, has ever been refused by the Barsi Light Railway, and on more than one occasion, boilers carried on one wagon on the light railway, have required two standard gauge wagons to convey them over the Great Indian Peninsula Railway.

In the coming year, a trial will be made of the system of carrying fully-loaded standard gauge wagons over the Barsi Light Railway on transportation cars. This system, which was originated by Mr. Calthrop on the 2 ft. 6 in. gauge Leek & Manifold Valley Light Railway in Staffordshire, has proved an unqualified success. On that line, the whole of the goods traffic is carried in standard gauge wagons, for which short lengths of standard gauge sidings are provided at every station. The saving of the cost of transhipment of goods at the junction has averaged about 2*s*. 6*d*. per wagon.

In order to utilise the maximum axle-load and attain sufficient weight and *vis inertia* to secure stability and absorb vibration at fairly high speeds, the carriages on the Barsi Light Railway have been designed of great length, width, and carrying capacity. They are 7 ft. 6 in. wide over all projections, and the original cars fitted with side doors are 40 feet long over headstocks, and 42 ft. 3 in. over buffers. The third-class cars have eight compartments with Government regulation seat accommodation for 64 passengers, but on holiday occasions have carried many more. The composite brake vans are composed of first and second class compartments, a guard's compartment and post office accommodation. The first-class compartments have sleeping arrangements and lavatories, which latter are fitted to the second-class also. The special saloon car for the use of Government officials and other distinguished passengers is of a luxurious character, the accommodation including an end inspection compartment, a long dining and sleeping saloon, an entrance and luggage vestibule, a lavatory and bathroom with hot and cold water, a kitchen and a servants' compartment, which is sufficient to show that narrowness of gauge is no impediment to long-distance travel under the most comfortable conditions.

The new "pilgrim" coaches, which will be a special feature of interest at the opening of the Pandharpur extension, are of a different type to the original carriages, being provided with three longitudinal seats, end doors, and end platforms. They are the longest and largest in India designed for use on this gauge, being 42 feet over headstocks, 45 feet over buffers, and with bodies the full width permitted — *viz.*, 7 ft. 6 in. — the latter arrangement necessitating the slight tapering of the pillars shown in the photographs. The alteration from side to end doors has been made with the object of reducing the work of the traffic staff, which will be most onerous during the continuance of the Pandharpur Fairs. These coaches are built in "set-trains" of four vehicles each, permanently coupled together, and are fitted with electric light, each "set-train" being provided with a dynamo and accumulators on one of its vehicles. Two composite brake vans fitted with dynamos will be available for attachment to any "set-train" whose dynamos or batteries may be temporarily out of order. The new locomotives are capable of hauling four "set-trains" coupled together.

Each pilgrim coach will carry 67 passengers (allowing the unnecessarily generous seat room of 19 1/2 inches required by Government regulations), but it is probable that having regard to the smaller room taken by women and children, nearly 100 passengers per car can be carried without discomfort. With the great hauling power of the locomotives, it is expected that from 1,200 to 1,500 passengers can be accommodated in each train carrying pilgrims to and from Pandharpur. There are no lining boards or other crannies to harbour dirt, and all surfaces are capable of being reached with liquid disinfectants. It is believed that the care thus taken will materially assist to lower the risks of epidemics at Pandharpur, and will be rewarded by an increased pilgrim traffic. The cost of these cars per passenger seated (Government regulation) is about 75 per cent only of that of ordinary third-class cars on the standard gauge of 5 ft. 6 in. Everything on the railway is of British manufacture.

From the opening of the line in 1897 to June 30, 1906, 673,063 passengers have been carried a total of 13,648,436 passengers miles, equal to an average of 1,949,776 passenger miles per carriage, and 496,222 tons have been lifted and carried a total of 10,815,775 ton-miles, equal to an average of 200,292 ton-miles per wagon. During the same period, the engines have travelled 278,544 miles at a total cost of £2,908 (Rs. 43,623) for maintenance and repairs, equal to £10·44 Rs. 157) per 1,000 miles. This gives an average of 51,212 engine-miles per engine at a total cost over the period of ten years of £538 (Rs. 8,078) per engine for maintenance and repairs.

That this little railway, worked under an independent administration in India, with its own board and officers in London, has been able to demonstrate its ability not only to live for a period of nine years on a mileage of less than 22 miles, under stress of plague and famine, but to pay increasingly satisfactory dividends to its shareholders, constitutes the strongest possible proof of its vitality, and of the advantages afforded by the high traffic capacity and efficiency of its rolling stock, combined with the small capital cost per mile of its track. Sound as its position has been in the past, the lowering of the incidence of administration charges due to the increase in open mileage from 21 $^3/_4$ to 80 miles, and the extension of the company's sphere of action to Tadwalla and Pandharpur, justify the expectation that the undertaking will enjoy a measure of still greater prosperity in the future.

REVIEW OF TRAFFIC QUESTIONS,

By C. COLSON,
CHIEF ENGINEER OF BRIDGES AND ROADS,
COUNCILLOR OF STATE OF FRANCE.

(*Revue politique et parlementaire.*)

Internal navigation in 1905.

Last year the river and canal traffic, just like the railway traffic, felt the happy effect of the general activity in industry and commerce. The increase was however much smaller on waterways than on railways, which is always the case when the requirements of the public suddenly grow. Only a railway has the necessary elasticity for adapting if not wholly, at least to a large extent, the activity of its operations to the needs of its clients; in France it is moreover compelled to set its wits to work to do so, controlled as it is by the existing legislation which neither allows it to refuse traffic in excess of its capabilities, nor to raise its rates so as to induce consignors to try other means of carriage, just as it is unable to reduce rates temporarily, in times of slackness, to secure the traffic which is lacking. Boats on the other hand only accept traffic which they can deal with without difficulty; when there is plenty of traffic they benefit by raising rates, but when the traffic is shrinking they only have to reduce them a little so as to alter to their advantage the division of the traffic between boats and railways, and to take away from the latter enough to make up for the reduction in the normal share. Then also in the quick and regular increase in water-carriage which has been going on from 1879, when the State again began to spend considerable sums on the improvement of waterways, without asking for any return for this capital, the momentary irregularities which have arisen in the development are nearly exclusively due to the climatic influences which facilitate or hinder the traffic on those ways, whereas railways are almost alone in being affected by the crises which can affect them in two ways: they suffer a considerable reduction in their receipts, when the traffic is abnormally reduced, and they have to contend with very great difficulties in carrying out the service, when the traffic increases suddenly.

We have already submitted to the readers of the *Revue*, the figures confirming the accuracy of these assertions, the figures on the sudden increase of 1879-82, 1888-91, and 1896-98, as well as on the depressions of 1884-87 and 1892-93. The general statistics of 1899-1901 give no indications of a general character on this point, because the development and subsequent cessation of supply of material and removal of spoil resulting from the works on the banks of the Seine, in connection with the exhibition, were a cause of too much disturbance in the variations in waterway traffic. But the progress in the growth of the traffic since the general crisis of 1901 supplies a new and striking confirmation. The figures in the following table show this :

YEAR.	TRAFIC, IN MILLIONS OF TON-KILOMETRES (IN MILLIONS OF ENGLISH TON-MILES).			PERCENTAGE OF INCREASE, AS COMPARED WITH PRECEDING YEAR.		
	Waterways.	Railways.	Total.	Waterways.	Railways.	Total.
1901 . . .	4,380 (2,679)	16,015 (9,794)	20,395 (12,473)	...	...	...
1902 . . .	4,465 (2,731)	16,171 (9,890)	20,636 (12,620)	1·9	1	1·2
1903 . . .	4,955 (3,030)	16,585 (10,143)	21,540 (13,173)	11	2·5	4·4
1904 . . .	4,968 (3,038)	16,551 (10,122)	21,519 (13,160)	...	...	...
1905 . . .	5,085 (3,110)	17,700 (10,825)	22,785 (13,935)	2·4	7	5·9

In the middling years 1902 and 1903, when the beginning increase was merely making up for the losses in 1901, the waterways took a much larger proportion than railways, and long before the latter resumed their normal condition. When improvement ceased in 1904, and was followed by a very slight set-back, waterways nevertheless continued to improve very slightly, whereas the traffic on railways decreased a little. But when in 1905 there was a sudden increase, hardly possible to foresee from the results of the preceding years, the railways had to provide for much the greater part.

Such provision was however only advantageous, for the work required did not exceed what the railways could do with the means at their command, means which had been gradually increased to the extent justified by the very slow average increase of traffic which had taken place in France during the previous twenty years. The companies consequently owed to the exceptional overplus of traffic the excellent financial results of the last financial year, which we recorded in the May number of this review; at the same time, they did not encounter any real difficulties in providing the services required. But in 1906 this was no longer the case. In the whole world, the development of traffic was by leaps and bounds, and everywhere at the present time the ordinary increase of traffic during autumn has set in with such intensity that it is extremely difficult to meet it. No doubt State railways and companies, warned by the improvements of 1905, have been trying to hasten the augmentation of their rolling stock. But wagon builders, pressed from all sides, for months past now have accepted no further orders except for delivery in the distant future ; and in all countries, we may say, there is a chorus of recrimination against the railways which can no longer cope with the requirements of their customers.

To what extent do waterways help them in these difficulties? Are waterways really a means for reducing such crises, as their partisans pretend, or does their existence tend, as we firmly believe, to aggravate them, owing to their incapacity of dealing, when traffic increases, with a part proportional to the importance of their function when traffic is normal? The figures necessary for giving a definite answer to this question will only be published a year later. But the facts observed during 1905, together with the experience acquired 1896-1900, enable us to foresee what this answer will be. As a first approximation, let us take some data which evidently do not supply a strict measure of the goods traffic, but which will enable us to form an idea of the order of magnitude of the increase. According to the rough figures published, the total railway receipts since the beginning of 1906, will exceed the figures for the corresponding period of 1905 by 4·5 per cent (¹); the figures for waterway traffic will, however, be a little lower than those for the preceding year. On the other hand, we know that in the Central and Midi regions, the want of water, the result of the prolonged drought, has been impeding for weeks the traffic on the Rhone and the canal traffic; so that not only all the increase of traffic in 1906, but also part of the ordinary traffic of the waterways is sent to the railway, which is already full up. In the North, the freight for coal to Paris, which at the same period of the previous year was 6 to 6·5 francs per ton (4*s.* 10*d.* to 5*s.* 3*d.* per English ton), being already higher than the year before, was raised to 7·5 francs (6*s.* 1*d.* per English ton). That being the case, the proportion of consignors which would apply to the railway by preference, is bound to increase, all the more so as they are certain, when applying to the railway, that the latter will not refuse to carry the goods, and is even compelled to compensate them for any losses they have suffered if the goods are not delivered within the time specified by law.

The situation is moreover just the same in Germany, as far as the difficulty of coping with the traffic is concerned. The State administrations which manage the railways ought however to have been ahead of our companies as regards the ordering of rolling stock, for they were not affected by the stop in the increase which in 1904 justified the French railways in exercising caution in their purchases; since the general set-back of 1901, the traffic on the German lines has been continually increasing; slow freight traffic increased from 31,920 million ton-kilometres (19,521 million English ton-miles) in 1901 to 37,483 million ton-kilometres (22,923 million English ton-miles) in 1904, the successive increases being 4 per cent in 1902, 8 per cent in 1903 and 5 per cent in 1904. The German administrations had thus long warning of the existing tendencies. Nevertheless their rolling stock proved inadequate for coping with the further increase of about 7 per cent which took place during 1905, and as a result, the service at the end of that year was disorganized to an extent the extreme seriousness of which the Prussian government was bound to recognize. The same phenomenon is occurring at the present time; the receipts from goods traffic have once more increased by 8 per cent since the beginning of the fiscal year (April 1, 1906), and again the railways can no longer cope with the increase. Now in this year as in the last, in Germany as in France, waterways, far from relieving railways, are unable to carry on their ordinary work, and that just at the time when needs increase. In 1905, the water-supply in the Elbe basin was deficient, and frost set in early in the winter; this compelled a number of the ordinary customers of the waterways to have recourse to the railways; in 1906, the low level of the Rhine, the result of an exceptionally dry summer, is preventing the carriage of coal on the waterways, and that just at the moment when there is not enough rolling stock on the railways and there is no country in the world which has any to spare. The wagons ordinarily used for the shuttle service between the coal pits or blast furnaces of Westphalia and the wharves on the Rhine must now carry, from terminal to terminal, the goods generally conveyed successively by rail and by boat, and the lack of rolling stock is thereby considerably aggravated.

(¹) The increase in the tonnage of goods is much more considerable than that in the receipts, when it is chiefly due to augmentation in the carriage of heavy goods, carried at low rates; thus in 1905, the ton-mileage of slow freight goods increased 7 per cent, whereas the total gross receipts only increased 3·8 per cent.

When there is a natural highway which presents such absolutely exceptional facilities as the Rhine, the advantages it offers in normal times to industry largely make up for such temporary inconveniences. But when there is talk of constructing artificial waterways or of altering so-called natural highways, actually not navigable, at large expense, under the pretext of relieving railways which are no longer equal to the work, it should never be forgotten that the difficulty of coping with the traffic, at very busy moments, would be very much smaller if the railways by themselves had to cope with it at ordinary times; for it is really the railways alone which have to meet all the sudden demands, and the relative importance of such sudden demands would be less if the railways were equipped to deal always with all the traffic, instead of ordinarily dealing with only three-fourths of it. Waterways participate in any unusual increase only to the extent it may suit them so to do; moreover, their irregularity often has a result that they must refuse part of their traffic just at the time of greatest need.

In Germany however, the disadvantages resulting from such crises are much less serious than in France, owing to the legislation in force. In the first place, the railways being operated by the State, they are not subject to the criticisms and orders of supervising authorities; the Minister of public works who has only himself to blame for any dilatoriness in ordering rolling stock, is more ready to find it excusable. Finally and especially, any delay in the supply of wagons, however serious, does not entail pecuniary claim against the railway administration. We have already explained in this paper how such is the case; this year again we had the opportunity of checking, from the best sources, the absolute accuracy of the information collected some years ago on this subject by the Extra Charges Commission. It is true that in Germany the time-limit within which a wagon must be supplied, once it has been promised, is much shorter than provided for in our special tariffs; but the administration fixes, *at its discretion*, when the time in question begins. The time only begins when the wagon has been *promised*, the promise must be *in writing*, and the employees have definite instructions to give no such promise unless the rolling stock required is *available at the station*. Under these conditions, it is evident that claims for delay can never be made in the case of full truck-loads, however serious the loss caused by the impossibility of keeping the service going properly. Now we know that in Germany, both owing to the nature of the traffic and the effect of the tariffs which make grouping almost a necessity, full truck-loads loaded by their consignors represent 95 per cent of the tonnage of slow freight goods. Actually the German railways are in a legal position similar to that of the waterways, only accepting traffic within the limits they can deal with, whereas French railways are compelled to carry traffic, no matter how much there is of it, within the times specified in the tariffs. The railways subjected to this legislation are the only industry in the world which has no right to refuse further orders when full up; that is a fact which must not be forgotten in times of crises like the present. It is only a few days ago that a manufacturer sent us on a letter in which a German mining company informed him that as it was unable to obtain trucks to despatch the coal it had sold to him, it was going to supply him, at the same price, with coal it would purchase for the purpose in England. The mine which had to cope with such a situation has no remedy against the railway; neither the Rhine, nor the Dortmund-Ems canal will protect German coal from the losses which such a situation entails.

An examination into the constituent elements of the traffic during the last few years affords further proof of the incorrectness of the assumption that the division of the traffic, between waterways and railways, would be effected spontaneously on the following bases : heavy goods by waterway, valuable goods by railway. No doubt very valuable goods are only conveyed by railway; quick and safe carriage is in this case of much greater importance than cost, and moreover, such consignments are too small for waterways to trouble about. But if we compare goods of medium value, such as cereals, wine, wood, sugar, castings, or even textiles, yarn, paper, with heavy goods such as coal, minerals, stone, etc., we find that it is more particularly in the case of the former that waterways, on ways where there are no tolls and where traffic can easily be dealt with, can become formidable competitors of railways. In the case of heavy goods, in fact, the toll proper only represents a small fraction of the whole charge made by the railway; the necessities of the case compel the railway to have a tariff but slightly higher than the true net cost of the carriage, and consequently, under such conditions, the regular railway rates hardly exceed those of the waterways. On the other hand, in the case of goods of medium value, the toll proper amounts to two-thirds or three-fourths of the charge made by the railway; consequently, waterways, if free from any such toll, have an enormous advantage. The railway which would nevertheless easily retain the traffic on its competing lines, by giving up part of the toll, is prevented from doing so by the opposition of the public authorities to any reduction limited to such lines. It is clear therefore, that the railway being obliged to earn dividends on its capital, cannot reduce its tolls generally to near the vanishing point, on the only traffic which is both extensive and capable of standing rates which are appreciably higher than the working expenses. Hence the railway is prevented from retaining this traffic, on lines where waterways compete, not owing to its inability to carry goods at as low rates as the waterways, but to the controlling authorities who prohibit the railway from making sacrifices in certain directions without general and impossible sacrifices. Now it is such traffic more especially which is carried on waterways.

The statistics in this connection give ten classes of goods conveyed by water, of which about four represent heavy goods and six the more valuable goods. No doubt this division is not quite accurate. Thus building materials conveyed by water include, in addition to a very large amount of sand and stone of no particular value, fairly costly lines such as cement and hydraulic lime; on the other hand, among agricultural products, consisting chiefly of wheat and wine, there are also some cargoes of beetroots, worth very little per ton. However, taking it altogether, the division of the goods, according to value, is fairly accurate in the subjoined table; we give, in millions of ton-kilometres (in millions of English ton-miles), the traffic in each class during the last three years:

HEAVY GOODS.	1903	1904	1905
Coal	2,254 (1,378)	2,188 (1,338)	2,235 (1,367)
Building materials, stone, earth	849 (519)	871 (533)	890 (544)
Manures and fertilizers	119 (73)	114 (70)	102 (62)
Ores	353 (216)	328 (200)	291 (178)
More valuable goods	3,575 (2,186)	3,501 (2,141)	3,518 (2,151)

MORE VALUABLE GOODS.	1903	1904	1905
Wood for burning and for carpentry	285 (174)	315 (193)	320 (196)
Metals and machinery	227 (139)	228 (139)	267 (163)
Manufactured goods	291 (178)	298 (182)	319 (195)
Agricultural produce and articles of food	535 (327)	575 (352)	620 (379)
Miscellaneous	32 (20)	32 (20)	33 (20)
Timber, rafted	10 (6)	9 (5)	8 (5)
Total	1,380 (844)	1,457 (891)	1,567 (958)

Naturally, heavy goods always preponderate, in the first place, because such form the greatest part of transport generally, secondly, because waterways have been constructed or improved more especially in mining districts; finally, because it is hardly possible to run the quick services necessary for other traffic on canals if they are at all busy. It is however none the less true, that in the industrial progress of the last two years, in which the traffic in coal, minerals, etc., has largely increased, the water-borne part of this traffic has become reduced rather than increased; all the increase has been in goods of medium value. Facts, as well as logic, contradict the sole serious economic argument advanced in support of the abolition of tolls on waterways, the argument of the nature of the water-borne traffic. The exemption benefits other goods than those intended more and more, whereas the railway, owing to its technical superiority, provides for the increase in heavy goods traffic by itself.

So far, we have based our arguments of the number of tons carried one mile, as the ton-mileage is the only element which takes into consideration, simultaneously, the quantity of the goods and the distances they are carried. The latter have considerably increased as a result of the very useful work of standardizing the waterways so that now they can nearly all be used by the Flemish pinnaces; in 1881, the average haul was 110 kilometres (68 miles), and in 1891 it was 140 kilometres (87 miles); now it is about 150 kilometres (93 miles). The figures bearing on this point are as follows for the last two years :

	1904		1905	
Number of tons (English tons) shipped.	32,607,447	(32,092,442)	34,030,467	(33,492,987)
Mean distance carried, in kilometres (in miles)	152	(94·5)	149	(92·6)
Total ton-kilometres (English ton-miles)	4,968,386,000	(3,038,507,000)	5,085,488,000	(3,110,123,000)

The slight fall in the mean distance is chiefly due to the increase in carrying sand, stone and rubbish in Paris and its neighbourhood; rubbish of all kind, delivered at the shoots set up on the quays, is used to fill up the sand pits from which the sand is brought on barges to Paris, or the hollows in connection with railway earthworks.

The traffic of the port of Paris (the river Seine, the Saint-Denis and Saint-Martin canals, connected with the Villette basin) continues to grow. In 1905 it amounted to :

Arrivals	5,763,864 tons	(5,672,829 English tons).
Departures.	2,507,747 —	(2,468,139 — —).
Transit.	1,504,506 —	(1,480,744 — —).
Internal	426,711 —	(419,971 — —).
Total . . .	10,202,828 tons	(10,041,683 English tons).

It has often been remarked, for a number of years now, that these figures exceed those for Marseilles by one-third and are three times as great as those for Havre. But one should not compare, as regards commercial importance, traffic the greater part of which consists of purely local carriage of rubbish and empties (which form the whole of the internal traffic), the rest consisting of goods of medium value brought from places 100 or 150 kilometres (62 or 93 miles) off, with the traffic of ports supplying important markets with goods which are often very valuable, and come by sea from the whole world. One would commit an even more serious error if one compared the traffic of ports where the chief business is shipping coal, minerals, or even cereals and wine, such as Cardiff, Rotterdam, Rouen or Genoa, with the traffic of great centres of international commerce, such as London, Liverpool, Hamburg, Havre or Marseilles. The same amount of traffic by no means represents anything like the same value in the two cases. It is none the less true that water-borne traffic is of considerable importance in Paris; the shipments received amount to $^4/_5$ and those despatched to $^9/_{10}$, of the corresponding figures for the railways. But no comparison can be made, especially in the case of outward shipments, between purely local traffic in rubbish of hardly any value, where water-carriage is preferred, owing to the location of the points where loading and unloading can take place, and the outward railway traffic in goods made in Paris, which are not sent by water owing to their great value and the care they require. Building materials form half of the inward traffic, coal one quarter; the rest consists of goods of medium value which can be conveyed by water, such as wood, wine and cereals imported viâ the port of Rouen.

In order to give an idea of the intensity of the chief currents of water-borne traffic, we can take the average circulation on the sections where local traffic is of but little importance, as compared with the through traffic; the average number of tons passing at any points on such sections show sufficiently well the importance of the flow of traffic there. We give below, in thousands of tons, the figures for a number of points on the more important currents, for 1881 (the first year in which statistics were drawn up as now), for 1894, for 1904 and for 1905 :

SECTIONS.	1881	1894	1904	1905
Seine, from Rouen to the junction with the Oise	678	1,430	1,957	2,019
Oise canal (North line to Paris).	1,600	2,789	3,701	3,704
Saint-Quentin canal (North lines to Paris and to the East, joint).	1,760	3,870	4,838	5,048
Oise canal to Aisne (line connecting North and East). . . .	...	1,412	1,700	1,841
Canal, Marne to Rhine (East lines to North and Paris) . . .	504	1,177	1,587	1,566
East Canal, North branch (East line to Belgium). . . .	74	695	1,132	1,077
Side canal to Loire (Paris line to Central districts)	407	616	864	791
Rhone, Lyons to Arles	183	218	201	289
Midi canal.	118	59	124	150

It will be noted that the development of traffic has been very rapid in northern France, but very slight in the southern districts. The greater and greater concentration of population at Paris has led to an enormous increase in the traffic on all the channels leading to it. On the Seine, where two thirds of the traffic consists of wood, corn, imported wines, products of industry of the Rouen district, the increase in water traffic has been obtained partly at the expense of the railway alongside (Rouen-Mantes section) on which traffic has been reduced, instead of increased; it fell from 1,547,000 tons in 1881 to 1,448,000 tons in 1905. This is an instance of the difficulty a railway has in retaining traffic of the kind, trammelled as it is by the difficulties resulting from the legal confirmation of the reduction of rates necessary for keeping traffic taken away by another carrier for whom our legislation reserves all its favours. In the case in question, the difficulty has been still further increased by the veto of protectionist opinion against the institution of what are miscalled import rates, which are considered as an extra advantage in favour of foreign imports, whereas such rates only tended to re-establish equilibrium between railway rates and the reduced freight on foreign goods on waterways which have been improved at great expense and freed from all tolls. The Seine, which for a long time was only used for agricultural and manufactured goods, is now also beginning to be used for supplying coal to the Paris district; the merchants who for a long time have been importing English coal into Rouen for local needs, have considerably increased their shipments up country, and the Westphalian coal mines have also made arrangements at Rouen for the transhipments of their produce, while the attempts of the French Western Railway to give increased facilities to the distribution of coal imported through Dieppe or through other ports where only railway transport is available, have always met with the greatest opposition, the interests of our collieries being the motive; the result is that the coal traffic up the Seine now amounts to nearly 500,000 tons, whereas the Dieppe-Paris traffic is falling off. And the State, after having thus itself taken away from the Company the traffic on its best lines, in trying to buy it out, bases its appeals on the increased demands under the head of the guarantee of interest.

In the northern and eastern districts, the progress in water traffic has coincided with a considerable development in the two chief industries which give rise to heavy traffic : mining and metallurgy. During the last twenty five years, the output of coal in the Nord and Pas-de-Calais has more than doubled, increasing from 9 million tons in 1881 to 23 millions in 1905; the output of iron ore in Meurthe-et-Moselle has quadrupled, increasing from 1,600,000 to 6,400,000 tons, and the metal industry, which is partly located near the mines, has grown correspondingly. The opening out of new ore deposits discovered in the neighbourhood of Briey, and the granting of concessions for them, has marked another step in the growth; besides the general prosperity which at present affects the whole world, through the nearly regular alternation of periods of prosperity and depression, we have to record in eastern France the commencement of a development in production of metal which results from the possession, on the spot, of minerals which competing industries have to seek far afield, and this development will no doubt be of a durable character and may in course of time assume enormous dimensions. Such being so, it was possible for waterway traffic to increase enormously, without preventing the growth of railway traffic from being still greater. The traffic in minerals from the East to the North has slightly decreased, owing to the increasing tendency of placing the blast furnaces nearer the ore beds; but as a result, the coal traffic in the opposite direction is increasing, as well as that in Belgian coal by the Eastern canal and that in North of France coal to Paris. For a long time, the Saint-Quentin canal has been thought to have arrived at its limit of capacity, receiving as it does two currents of coal, the one supplying the continually growing population of Paris, and the other being the coal which our northern coal-pits send to the eastern districts. But the doubling of locks has enabled it to face the increase of the last few years, and no doubt the doubling of the single tunnel now existing at the watershed will give it fresh scope, and that with much smaller expenditure than in the case of the new Nord canal recently declared a work of public utility. As to the traffic in goods of medium value, it develops much more slowly on the East and Nord canals than on the Seine ; this is due to the difficulties arising from the great number of locks and the congestion.

In central France, the improvement of the canals has resulted in some growth in the traffic. But those waterways have no sources of supply similar to those found in the northern and eastern districts; the output of the coal fields does not appear capable of increase, and there are no longer any large metallurgical works, now that processes have been invented for utilizing the ores found in the eastern districts, which contain sulphur or phosphorus. Manufactured goods of all kinds form a material part of the traffic

Finally in the south, there is little water-borne traffic. The Rhone, in spite of the sums spent in improvements, remains a too indifferent means of conveyance for traffic to develop to any considerable extent; the fundamental difficulties which arise from too rapid a fall keep rates high, so that the traffic cannot grow; the service of lighters towed on the sea now connect the river and Marseilles, just as well and perhaps better than the canal on which so much money is going to be spent.

The traffic on the Midi canal has increased a little, both through the improvements in wine-growing and through the abolition of tolls which took place in 1898. The progress of traffic since that abolition, together with the facts observed on the Seine, show that it is possible for a railway to retain the traffic against waterway competition, when that railway has the power to reduce its rates locally, without having therefore to extend any resulting loss to all the lines of its system. The Midi canal, just like the Seine, runs parallel with the trunk lines of the railways in the district. No doubt technically speaking, it is much inferior as a waterway to the Seine; but on the other hand, its length does not differ much from that of the railway, whereas from Rouen to Paris the waterway is twice as long as the railway, and that is certainly a consideration. The chief items conveyed are wine and barrels, that is to say, goods which in price and quality compare with those conveyed on the Seine. It was formerly asserted that what alone prevented the canal traffic from developing, were the exorbitant rates charged by the Midi Railway Company. In 1898, when the lease of the company fell in, the tolls were abolished; the tolls on the canal to the Garonne, which forms an extension of the Midi canal, were abolished at the same time. But the railway company held a concession of this extension, and it could not be bought without the consent of the company, unless the whole company was bought out. The company did not ask for any money as its price for giving up the canal; it was satisfied with a reduction in the rate of interest of its guaranteed debt. But knowing that once the canals were freed from tolls, it would no longer be authorized to reduce the rates, on the lines competed with, to the extent required so as to retain the traffic the canals would try to capture, it obtained, in the convention for the purchase of the extension, the insertion of a clause giving it power to reduce materially the rates on its Bordeaux-Cette line. This reduction has resulted for it in an annual loss, of about 5 millions of francs (£200,000), on the traffic in question; but it has kept nearly the whole of that traffic. If we take the tonnage of goods on the Bordeaux-Cette line, for the years included in our table referring to canals, given above, we find it was 942,000 tons in 1894; 1,185,000 tons in 1901; 1,221,000 tons in 1904; and 1,321,000 tons in 1905. The mean railway traffic between 1894 and 1905 increased 279,000 tons, whereas the canal traffic increased 91,000 tons. No doubt, proportionately to what the initial traffic was, the increase has been greater on the canal, as there the initial traffic was small; thus there has been a slight transfer in favour of the canal, but this transfer is insignificant as compared with the total traffic. Thus the abolition of tolls has not prevented the railway from retaining the traffic; this it has been enabled to do by the special circumstances allowing it to adjust its rates to the new state of affairs on the line concerned. The 27 millions (£1,080,000) which the State has expended in order to purchase the Midi canal from the company which held the concession, when the lease which the railway company had held fell in, have merely had the result of reducing railway rates in the district concerned to an abnormally low level, and this advantage is obtained at the expense of the other tax-payers, as the payment made each year by the railway company in connection with its guaranteed debt, are reduced to a corresponding extent. The advantages as far as the district is concerned would have been the same, and the loss to the railway (and consequently to the State) still greater, if the abolition of tolls had not been accompanied with the modification of the railway rates, and the results had been the transfer of the traffic to the waterways. But this example shows well that reductions in cost of carriage, due to the presence of canals on which no tolls are paid, are in the nature of favours to the districts concerned, and are not due to any technical superiority of water carriage to railway carriage.

MISCELLANEOUS INFORMATION

[725 .31]

1. — Proposed down-town terminal of the Hudson River tunnel system.

Figs. 1 and 2, pp. 467 and 468.

(*Railway Age.*)

The magnitude of the tunnel system now being built under the Hudson River by The Hudson Companies for the Hudson & Manhattan Railroad which will operate the tunnels, was shown in an illustrated article in *The Railway Age* of November 16, 1906. A plan of the down-town terminal at the track level was there presented. The two office buildings which will be built on the terminal site, on Church street, from Cortlandt to Dey street, and from Dey to Fulton street, will be twenty-two stories high above the surface, and will extend 75 feet below the surface to bed rock. The north building will be known as the Fulton building and the south buidling as the Cortlandt building. The accompanying engravings (figs. 1 and 2) from photographs of the architects' drawings show the exterior appearance of the building and indicate the proposed inside arrangement at the track, concourse, street and floor levels. A passage-way from the concourse level leads to the New York Rapid Transit Subway station under Broadway at John street.

The terminal buildings will be when completed the largest office structure in the world. There will be space on the 22 floors for 4,000 offices, and some of the largest business interests in the country will be located in the buildings. It is estimated that the permanent occupants will number at least 10,000 persons, who will be served by 22 express and 17 local elevators.

The structure will be a fine example of Italian renaissance architecture, and will occupy about 70,000 square feet of ground. Up to the fourth floor, the buildings will be built of polished granite and Indiana limestone, and above that, of brick and terra cotta.

A prominent feature of the structure will be an arcade, which will be a great glass enclosed passage, much larger than any of the famous European arcades, and lined with shops and booths. The public halls will be of marble, handsomely decorated, and the interior finish will be in hard wood throughout.

The buildings have been designed to secure the maximum amount of daylight, and will have 5,000 windows, while 30,000 incandescent lamps will provide artificial light. There will be installed a large electric storage battery, which will be held as a reserve in the event of any accident to the electric generating plant.

Passengers will enter the building at the street level, and reach the station by means of easy stairways, incline planes and elevators. In the concourse, there will be waiting

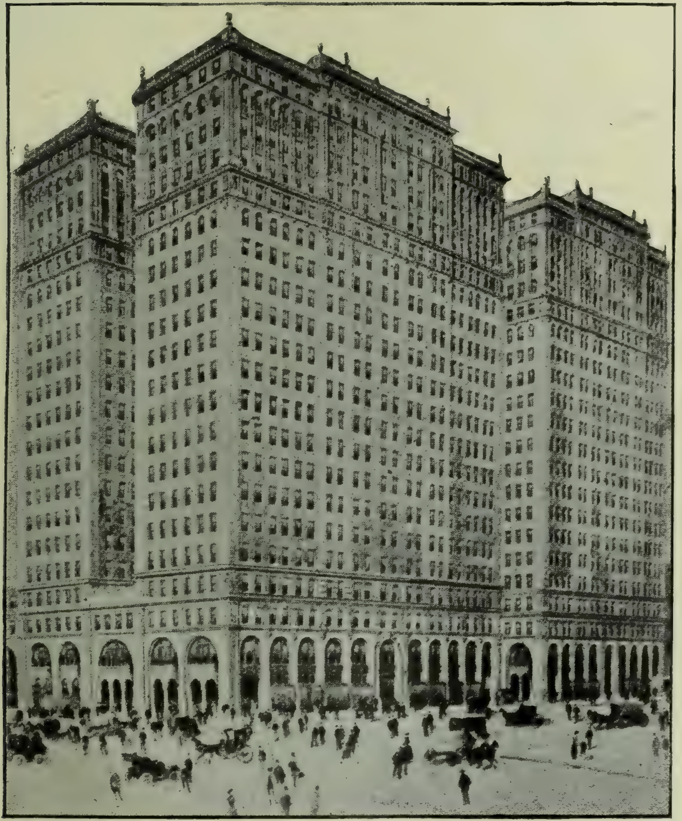


Fig. 1. — Proposed down-town terminal of the Hudson River tunnel system.

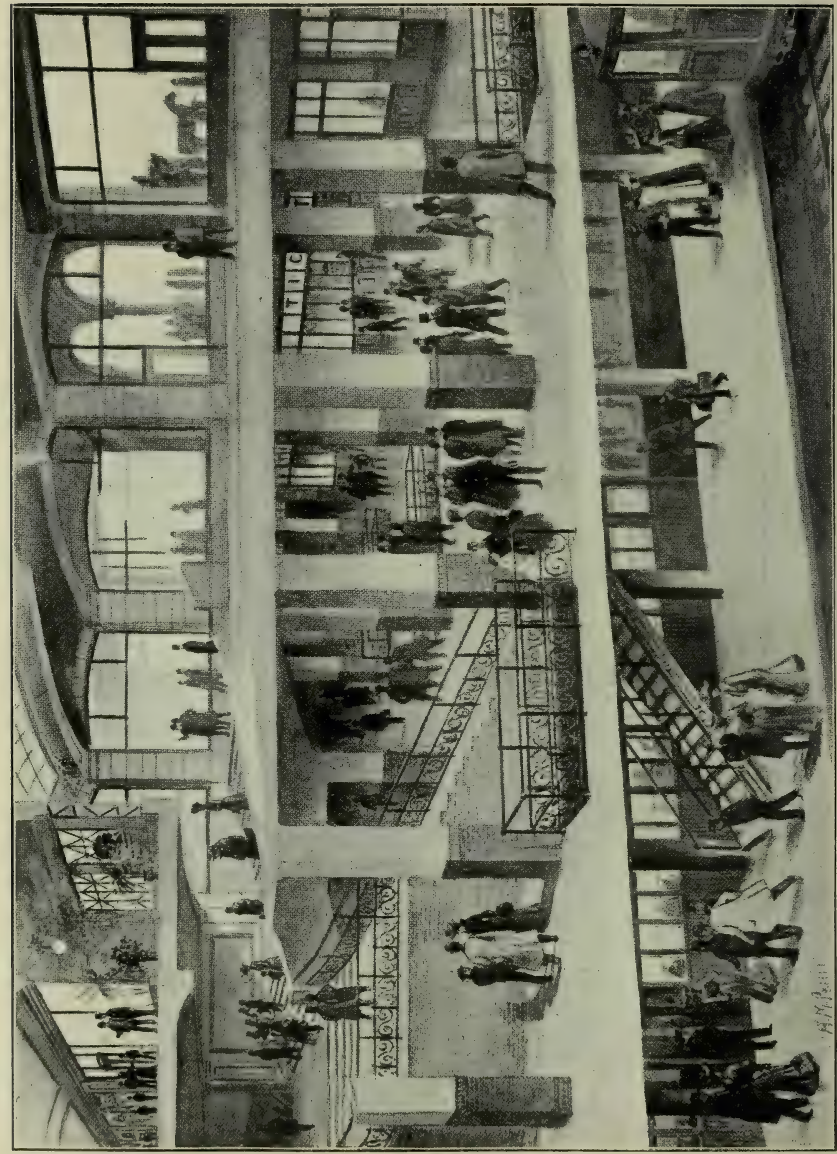


Fig. 2. — Proposed down-town terminal of the Hudson River tunnel system. — Track level, concourse, street level and first floor.

rooms, in which will be found comfortable benches, retiring rooms, ticket offices, telegraph stations, telephone booths, flower booths and newspaper kiosks, retaurants, lunch counters, boot-black stands and other conveniences of a modern railroad station.

The buildings will have a complete conduit system, to provide for telegraph, telephone and stock ticker systems, and compressed air and vacuum cleaning apparatus.

Below the concourse floor, as shown in the engraving, will be the train platforms, which will be reached from the concourse floor by means af stairways and elevators. There will be five tracks and six platforms. The cars will have center as well as end doors, and in order to facilitate loading and unloading, the passengers will be discharged on an unloading platform on one side of the car. The doors on that side of the car will then be closed and the doors on the opposite side opened, to admit passengers from the loading platform, thus preventing any confusion between the incoming and outgoing passengers. The cars will be of steel and have a seating capacity of 50 persons each. It is proposed to operate eight-car trains during the rush hours, on a headway of 1 1/2 minutes. The passage under the river will probably average three minutes, so that a resident of Jersey City should be able to reach the Manhattan terminal in from five to ten minutes. The residents of Jersey City will thus be actually nearer the Manhattan shopping and theater district, in point of time, than the residents of the Bronx.

From this station, the traveller may without at any time going from under cover, be landed in the Pennsylvania, Erie Lackawanna stations in Jersey City, or in the Grand Central station in New York, by means of the Interborough Rapid Transit subway, and when the extension of the Rapid Transit subway of Brooklyn has been completed, it will be possible to reach the Flatbush avenue terminal of the Long Island Railroad in Brooklyn. The passenger may also reach under cover the Sixth and Ninth avenue lines of the elevated railroad system, or avail himself of the surface lines which pass the building.

The inspiration of the work, as a whole, comes from William G. McAdoo, president of the New York & Jersey Railroad, and the Hudson & Manhattan Railroad companies, and from Walter G. Oakman, formerly president of the Guaranty Trust Company, and now president of the Hudson Companies. It was the combined activity of these two men, backed by the banking house of Harvey Fisk & Sons, that made the enterprise possible. The engineering features are being worked out by Charles M. Jacobs, chief engineer, and J. Vipond Davies, deputy chief engineer. The architects are Clinton and Russell.

[656 .254 (.45)]

2. — The reform in the Italian passenger tariff.

(*Zeitung des Vereins.*)

The radical reform in the passenger tariff, which came into force on the Italian State Railway on November 1, 1906, is curiously enough not much commented on by the public and the press. It is observed that even at present the Italian railways, owing to want of sufficient permanent way and rolling stock, are unable to cope with the growing traffic, and surprise is expressed at the measures taken by the administration to stimulate the traffic, whereas until now its policy appeared not seldom to be to limit, by restrictive measures, the traffic on the congested lines. It is however doubtful whether the material reductions in the new tariff, particularly as regards long distances, will much increase the number of passengers. Statistics compiled six years ago showed that the passengers-mileage per inhabitant in Italy was one sixth that of Germany, in spite of the many foreign visitors to Italy. In no other civilized country of Europe is as much traffic carried by methods dating back to ante-railway times as in Italy. The reason for this is not only the high tariff, but also the incompleteness of the system and the uncomfortable travelling, due to the bad state of much of the rolling stock, and the bad organization of the service (unpunctuality, slow trains, not enough trains). The small amount of passenger traffic is deplored, by many, not only on general and economic, but also on political grounds; the Italian, travelling but little, is generally only acquainted with his own special neighbourhood, and consequently intercourse and cooperation between the different districts is made more difficult and they progress more slowly. The " regionalism " and the " campanilism ", the little-state policy with its narrow-minded points of view, still to be found in many parts of Italy, are largely due to the small amount of intercourse between the districts which are some distance apart.

It seems that the new reform has been introduced principally for this reason. The zone tariff, as used in Holland, Sweden, Norway, Russia and especially Austria, has been applied. But whereas in the last country, the one most suitable for comparison with Italy, there are only four zones (from 1 to 150 [0·6 to 93·2 miles], from 151 to 300 [93·8 to 186·4 miles], from 301 to 600 [187 to 372·8 miles], and above 600 kilometres [372·8 miles]), there are seventeen in Italy, and the fares are consequently much reduced, particularly in the case of long journeys. The following are the rates of the new Italian tariff:

DISTANCE.	1st class.	2nd class.	3rd class.
151 kilometres (93·8 miles).	19·25 lire (15*s.* 4·80*d.*)	13·50 lire (10*s.* 9·60*d.*)	8·75 lire (7*s.* 0*d.*)
200 — (124·3 —).	24·10 — (19*s.* 3·36*d.*)	16·85 — (13*s.* 5·76*d.*)	10·90 — (8*s.* 8·64*d.*)
300 — (186·4 —).	33·50 — (£1. 6*s.* 9·68*d.*)	23·30 — (18*s.* 7·68*d.*)	15·05 — (12*s.* 0·48*d.*)
400 — (248·6 —).	42·00 — (£1.13*s.* 7·20*d.*)	28·80 — (£1. 3*s.* 0·48*d.*)	18·55 — (14*s.* 10·08*d.*)
500 — (310·7 —).	49·50 — (£1.19*s.* 7·20*d.*)	33·30 — (£1. 6*s.* 7·68*d.*)	21·30 — (17*s.* 0·48*d.*)
600 — (372·8 —).	56·00 — (£2. 4*s.* 9·60*d.*)	36·80 — (£1. 9*s.* 5·28*d.*)	23·35 — (18*s.* 8·16*d.*)
700 — (435·0 —).	61·00 — (£2. 8*s.* 9·60*d.*)	39·80 — (£1.11*s.* 10·08*d.*)	25·35 — (£1. 0*s.* 3·36*d.*)
800 — (497·1 —).	64·75 — (£2.11*s.* 9·60*d.*)	42·55 — (£1.14*s.* 0·48*d.*)	27·30 — (£1. 1*s.* 10·08*d.*)
900 — (559·2 —).	68·00 — (£2.14*s.* 4·80*d.*)	44·80 — (£1.15*s.* 10·08*d.*)	28·80 — (£1. 3*s.* 0·48*d.*)
1,000 — (621·4 —).	71·00 — (£2.16*s.* 9·60*d.*)	46·80 — (£1.17*s.* 5·28*d.*)	30·05 — (£1. 4*s.* 0·48*d.*)
1,100 — (683·5 —).	74·00 — (£2.19*s.* 2·40*d.*)	48·80 — (£1.19*s.* 0·48*d.*)	31·30 — (£1. 5*s.* 0·48*d.*)
1,200 — (745·7 —).	77·00 — (£3. 1*s.* 7·20*d.*)	50·80 — (£2. 0*s.* 7·68*d.*)	32·55 — (£1. 6*s.* 0·48*d.*)
1,300 — (807·8 —).	80·00 — (£3.4*s.*)	52·80 - (£2. 2*s.* 2·88*d.*)	33·80 - (£1. 7*s.* 0·48*d.*)
1,400 — (869·9 —).	83·00 — (£3. 6*s.* 4·80*d.*)	54·80 — (£2. 3*s.* 10·08*d.*)	35·05 — (£1. 8*s.* 0·48*d.*)
1,500 — (932·0 —).	86·00 — (£3. 8*s.* 9·60*d.*).	56·80 — (£2. 5*s.* 5·28*d.*)	36·30 — (£1. 9*s.* 0·48*d.*)
1,550 — (963·1 —).	87·50 — (£3.10*s.*)	57·80 — (£2. 6*s.* 2·88*d.*)	36·80 — (£1. 9*s.* 5·28*d.*)

The distances are rounded off, according to their length, in to zones of 5, 10 and 20 kilometres

(3·1, 6·2 and 12·4 miles). The administration, taking as basis the principle that express trains only are in question in the case of long distances, charge no extra rate for such trains (all classes). Tickets for distances up to 100 kilometres (62·1 miles) are available for one day; up to 1,000 kilometres (621·4 miles) the journey can be broken once per 300 kilometres (186·4 miles); above 1,000 kilometres (621·4 miles) the journey can be broken five times.

Until now Italy, like Germany, France, Switzerland and Belgium, had a uniform rate per kilometre, but charged the highest unit rate for each class. The new tariff provides reductions when the distance exceeds 150 kilometres (93·2 miles); the reductions mount to 60 per cent in the case of very long distances. The following table shows some typical instances of the reductions resulting from the new tariff:

LINE.	Distance, in kilometres (in miles).	Old fare, in lire.			New fare, in lire.		
		1st class.	2nd class.	3rd class.	1st class.	2nd class.	3rd class.
Turin-Rome	658 (408·9)	84·00 (£3.7*s.* 2·40*d.*)	58·80 (£2.7*s.* 0·48*d.*)	38·20 (£1.10*s.* 6·72*d.*)	59·40 (£2.7*s.* 6·24*d.*)	38·60 (£1.10*s.* 10·56*d.*)	24·75 (19*s.* 9·60*d.*)
Naples-Venice . . .	800 (497·1)	102·10 (£4.1*s.* 8·16*d.*)	71·50 (£2.17*s.* 2·40*d.*)	46·40 (£1.17*s.* 1·44*d.*)	64·75 (£2.11*s.* 9·60*d.*)	42·55 (£1.14*s.* 0·48*d.*)	27·30 (£1.1*s.* 10·08*d.*)
Milan-Naples. . . .	884 (549·3)	112·80 (£4.10*s.* 2·88*d.*)	79·00 (£3.3*s.* 2·40*d.*)	51·30 (£2.1*s.* 0·48*d.*)	67·80 (£2.14*s.* 2·88*d.*)	44·70 (£1.15*s.* 9·12*d.*)	28·55 (£1.2*s.* 10·08*d.*)
Modane-Brindisi. . .	1,190 (739·4)	150·85 (£6.0*s.* 8·16*d.*)	106·30 (£4.5*s.* 0·48*d.*)	69·05 (£2.15*s.* 2·88*d.*)	76·50 (£3.1*s.* 2·40*d.*)	50·60 (£2.0*s.* 5·76*d.*)	32·30 (£1.5*s.* 10·08*d.*)
S. Eufemia-Pontedera .	1,296 (805·3)	161·95 (£6.9*s.* 6·72*d.*)	113·35 (£4.10*s.* 8·16*d.*)	73·65 (£2.18*s.* 11·04*d.*)	79·10 (£3.3*s.* 3·36*d.*)	52·40 (£2.1*s.* 11·04*d.*)	33·55 (£1.6*s.* 10·08*d.*)
Palermo-Iselle . . .	1,703 (1,058·2)	217·35 (£8.13*s.* 10·56*d.*)	152·15 (£6.1*s.* 8·64*d.*)	98·80 (£3.19*s.* 0·48*d.*)	87·50 (£3.10*s.*)	57·80 (£2.6*s.* 2·88*d.*)	36·80 (£1.9*s.* 5·28*d.*)
Girgenti-Modane. . .	1,788 (1,111)	221·80 (£8.17*s.* 5·28*d.*)	155·25 (£6.4*s.* 2·40*d.*)	100·85 (£4.0*s.* 8·16*d.*)	87·50 (£3.10*s.*)	57·80 (£2.6*s.* 2·88*d.*)	36·80 (£1.9*s.* 5·28*d.*)

The following information, which has reached us from another quarter, gives further particulars of the reform:

1° For distances not exceeding 150 kilometres (93·2 miles), the fares remain unchanged;

2° For distances of 151 to 270 kilometres (93·8 to 167·8 miles), the fares are calculated for each kilometre (0·6 mile) and apply to all the express trains; the present rates, which are lower, continue to apply to the ordinary trains. The unit rate decreases a little as the distance increases. The following table gives instances of these fares:

LENGTH OF JOURNEY.	1st class.	2nd class.	3rd class.
151 kilometres (93·8 miles)	19·25 lire (15*s.* 4·80*d.*)	13·50 lire (10*s.* 9·60*d.*)	8·75 lire (7*s.* 0*d.*)
191 — (118·7 —)	23·20 — (18*s.* 6·72*d.*)	16·25 — (13*s.* 0*d.*)	10·50 — (8*s.* 4·80*d.*)
231 — (143·5 —)	27·15 — (£1.1*s.* 8·64*d.*)	19·25 — (15*s.* 4·80*d.*)	12·25 — (9*s.* 9·60*d.*)
270 — 167·8 —)	30·80 — (£1.4*s.* 7·68*d.*)	21·50 — (17*s.* 2·40*d.*)	13·85 — (11*s.* 0·96*d.*)

3° For distances of 271 to 650 kilometres (168·4 to 403·9 miles), the fares are calculated by 5-kilometre (3·1 mile) zones (451 kilometres [280·2 miles] and upwards, the third class fares are by 10-kilometre [6·2 mile] zones), the unit rate being decreased as the distance increases. The following table gives instances of these fares :

LENGTH OF JOURNEY.	1st class.	2nd class.	3rd class.
From 271 to 275 kilometres (from 168·4 to 170·9 miles). . .	31·25 lire (£1.5*s.*)	21·80 lire (17*s.* 5·28*d.*)	14·05 lire (11*s.* 2·88*d.*)
— 346 to 350 — (— 215 to 217·5 —). . .	38·00 lire (£1.10*s.* 4·80*d.*)	26·30 lire (£1.1*s.* 0·48*d.*)	17·05 lire (13*s.* 7·68*d.*)
— 446 to 450 — (— 277·1 to 279·6 —). . .	46·00 lire (£1.16*s.* 9·60*d.*)	31·30 lire (£1.5*s.* 0·48*d.*)	20·05 lire (16*s.* 0·48*d.*)
— 546 to 550 — (— 339·3 to 341·8 —). . .	53·00 lire (£2.2*s.* 4·80*d.*)	35·30 lire (£1.8*s.* 2·88*d.*)	22·55 lire (18*s.* 0·48*d.*)
— 646 to 650 — (— 401·4 to 403·9 —). . .	59·00 lire (£2.7*s.* 2·40*d.*)	38·30 lire (£1.10*s.* 7·68*d.*)	24·55 lire (19*s.* 7·68*d.*)

4° Finally, for distances of 651 to 1,550 kilometres (404·5 to 963·1 miles), the fares are calculated by 10-kilometre (6·2 mile) zones (851 kilometres [528·8 miles] and upwards, the third class fares are by 20-kilometre [12·4 mile] zones), the unit rate always decreasing as the distance increases. The following table gives instances of these fares :

LENGTH OF JOURNEY.	1st class.	2nd class.	3rd class.
From 651 to 660 kilometres (from 404·5 to 410·1 miles). .	59·40 lire (£2.7*s.* 6·24*d.*)	38·60 lire (£1.10*s.* 10·56*d.*)	24·75 lire (19*s.* 9·60*d.*)
— 751 to 760 — (— 466·7 to 472·3 —). .	63·35 lire (£2.10*s.* 8·16*d.*)	41·55 lire (£1.13*s.* 2·88*d.*)	26·70 lire (£1.1*s.* 4·32*d.*)
— 851 to 860 — (— 528·8 to 534·4 —). .	66·80 lire (£2.13*s.* 5·28*d.*)	44·00 lire (£1.15*s.* 2·40*d.*)	28·30 lire (£1.2*s.* 7·68*d.*)
— 861 to 870 — (— 535 to 540·6 —). .	67·10 lire (£2.13*s.* 8·16*d.*)	44·20 lire (£1.15*s.* 4·32*d.*)	
— 1,051 to 1,060 — (— 653 to 658·7 —). .	72·80 lire (£2.18*s.* 2·88*d.*)	48·00 lire (£1.18*s.* 4·80*d.*)	30·80 lire (£1.4*s.* 7·68*d.*
— 1,061 to 1,070 — (— 659 3 to 664·9 —). .	73·10 lire (£2.18*s.* 5·76*d.*)	48·20 lire (£1.18*s.* 6·72*d.*)	
— 1,251 to 1,260 — (— 777·3 to 782·9 —). .	78·80 lire (£3.3*s.* 0·48*d.*)	52·00 lire (£2.1*s.* 7·20*d.*)	33·30 lire (£1.6*s.* 7·68*d.*)
— 1,261 to 1,270 — (— 783·6 to 789·2 —). .	79·10 lire (£3.3*s.* 3·36*d.*)	52·20 lire (£2.1*s.* 9·12*d.*)	
— 1,541 to 1,550 — (— 957·6 to 963·1 —). .	87·50 lire (£3.10*s.*)	57·80 lire (£2.6*s.* 2·88*d.*)	36·80 lire (£1.9*s.* 5·28*d.*)

Above 1,550 kilometres (963·1 miles), the rate remains constant. Tickets for distances up to 100 kilometres (62·1 miles) are available one day; there may be one break in a journey up to 300 kilometres (186·4 miles), two breaks up to 600 kilometres (372·8 miles), three up to 900 kilometres (559·2 miles), four up to 1,000 kilometres (621·4 miles); above 1,000 kilometres, five.

The luggage rates are fixed in a similar manner. Thus for every 10 kilograms (22 lb.) of luggage, the charge is : from 151 to 155 kilometres (93·8 to 96·3 miles), 0·70 lira (6·72*d.*); from 251 to 255 kilometres (156 to 158 5 miles), 1·06 lire (10·18*d.*); from 351 to 355 kilometres (218·1 to 220 6 miles), 1·39 lire (1*s.* 1·34*d.*); from 451 to 460 kilometres (280·2 to 285·8 miles), 1·69 lire (1*s.* 4·22*d.*); from 551 to 560 kilometres (342·4 to 348 miles), 1·93 lire (1*s.* 6·53*d.*); from 651 to 660 kilometres (404·5 to 410·1 miles), 2·13 lire (1*s.* 8·45*d.*); from 751 to 760 kilometres (466·7 to 472·3 miles), 2·27 lire (1*s.* 9·79*d.*): from 851 to 860 kilometres (528·8 to 534·4 miles), 2 37 lire (1*s.* 10·75*d.*); from 951 to 970 kilometres (590·9 to 602·7 miles), 2·43 lire (1*s.* 11·33*d.*) ; from 1,051 to 1,070 kilometres (653 to 664·9 miles), 2·49 lire (1*s.* 11·90*d.*); from 1,151 to 1,170 kilometres (715·2 to 727 miles), 2·55 lire (2*s.* 0·48*d.*); from 1,351 to 1,370 kilometres (839·5 to 851·3 miles), 2·67 lire (2*s.* 1·63*d.*); from 1,431 to 1,450 kilometres (889·2 to 901 miles) and upwards, 2·72 lire (2*s.* 2·11*d.*).

The price of the combination coupon tickets of the German Railway Union is not affected; the alterations in the prices of the combined Italian circular tickets are given in a special table. Alterations only occur in the case of distances exceeding 1,000 kilometres (621·4 miles), as well as in the coupons of foreign circular tickets, the coupons for the frontier stations of Ventimiglia, Modane, Domodossola, Luino, Chiasso, Ala, Pontebba and Udine. The price of Italian circular and return tickets is calculated according to the zone tariff : the corresponding double unit rate is applied to half the length of the whole journey.

[**656 .256**]

3. — Block signals on American Railroads.

(*The Railway Age.*)

The accompanying table (p. 474 and 475) shows the mileage of railroads in the United States protected by block signals at the close of the year 1906. In a later issue, *The Railway Age* will present comprehensive statistics covering the interlocking plants installed on American railroads. In compiling the data herewith, four classes of signals have been distinguished : 1° Automatic block semaphere or disc signals, which are installed on 9,421·2 miles of road, of which 60 per cent has two or more tracks; 2° Staff or tablet block signals, for which the total reported is 220·8 miles; 3° Manual controlled telegraph block signals, which are used on 1,819·4 miles of road, 722·1 miles having two or more tracks; 4° Manual telegraph block signals, for which the total is 39,776·5 miles. The grand total reported as operated under block signals is 51,237·9 miles.

The most striking feature of the table, is the large agregate of the mileage of the Harriman lines equipped with automatic signals, the total for the Southern Pacific and Union Pacific systems (including the Oregon Railroad & Navigation Company and the Oregon Short Line) being 2,278·7 miles of road, or over 24 per cent of the total automatic signals reported. This total does not include 223 miles of single and 243 miles of double track on the Union Pacific which will be equipped with automatic signals within ninety days. Automatic signals will be substituted on the 20 miles now protected by telegraph block on the Southern Pacific.

NAME OF ROAD.	Automatic block, in miles.			Manual telegraph block, in miles.			Manual controlled telegraph block, in miles.			Staff or tablet block.		Grand total, in miles.
	Single track.	Two or more tracks.	Total.	Single track.	Two or more tracks.	Total.	Single track.	Two or more tracks.	Total.	Miles.	No. blocks.	
Alabama Great Southern	28·3	...	28·3	2	...	2	...	...	...	...	...	30·3
Ann Arbor	...	...	...	...	1·5	1·5	...	...	...	...	...	1·5
Atchison, Topeka & Santa Fe	68·8	80·4	149·2	820·4	242·2	1,062·6	...	...	...	27·8	7	1,239·6
— — — (Gulf System)	...	...	17	...	...	...	...	...	...	6	1	23
— — — (Coast Lines)	8	1	9	...	...	...	...	...	...	4	2	13
Atlantic City	...	87	87	...	...	...	...	...	...	...	...	87
Atlantic Coast Line	...	...	...	431·7	54·5	486·2	...	...	...	...	...	486·2
Baltimore & Ohio and Baltimore & Ohio South-western	...	102·4	102·4	308·4	373·5	681·9	...	...	...	...	...	784·3
Bessemer & Lake Erie	...	...	...	135·3	61·2	196·5	...	...	...	...	...	196·5
Boston & Albany	0·4	175·9	176·3	...	8	8	...	...	...	...	...	184·3
Boston & Maine	...	(1) 80·7	80·7	(2) 21·7	97·1	118·8	...	4·8	4·8	...	...	204·3
Boston Elevated	...	8·8	8·8	...	...	...	...	...	...	...	...	8·8
Boston, Revere Beach & Lynn	...	9·8	9·8	...	...	...	...	...	...	...	...	9·8
Buffalo, Rochester & Pittsburg	...	...	...	378·8	107	485·8	...	...	...	...	...	485·8
Central of Georgia	...	...	...	51	9	60	...	...	...	...	...	60
Central of New Jersey	...	469	469	...	...	...	...	...	...	...	...	469
Chesapeake & Ohio	...	...	...	890·9	237·6	1,128·5	166·2	21·9	188·1	9·2	10	1,325·8
Chicago & Alton	288·4	127	415·4	343·4	44·6	388	...	...	...	11·4	2	814·8
Chicago & Eastern Illinois	6·1	101·6	107·7	...	...	...	137·1	...	137·1	...	...	244·8
Chicago & Northwestern	...	455	455	2,871·2	386·6	3,257·8	...	...	...	...	...	3,712·8
Chicago & Western Indiana and Belt Railway of Chicago	...	7·5	7·5	...	...	...	...	19·8	19·8	...	...	27·3
Chicago, Burlington & Quincy	...	28	28	7,796	468	8,264	3	...	3	...	...	8,295
Chicago Great Western	...	4·8	4·8	309	...	309	...	...	...	19	4	332·8
Chicago, Milwaukee & St. Paul (4)	7	29·5	36·5	2,593·6	355·7	2,949·3	2	...	2	8	4	2,995·8
Chicago, Rock Island & Pacific	...	15·5	15·5	...	499	499	...	...	...	4·7	3	519·2
Chicago, St. Paul, Minneapolis & Omaha	3·5	6·5	10	...	...	...	...	...	...	...	...	10
Chicago Terminal Transfer	...	4	4	...	...	...	...	...	...	...	...	4
Cincinnati, Hamilton & Dayton	...	...	...	73	27·9	100·9	...	...	...	...	...	100·9
Cincinnati, New Orleans & Texas Pacific	281·1	19 8	300·9	...	...	...	7·5	...	7·5	5·6	3	314
Cleveland, Cincinnati, Chicago & St. Louis	...	...	...	577	275·2	852·2	...	...	...	...	...	852·2
Cumberland & Pennsylvania	...	...	...	8 5	...	8·5	...	...	...	...	...	8·5
Cumberland Valley	...	...	...	18·8	16·7	35·5	...	...	...	...	...	35·5
Delaware & Hudson	142	109	251	...	...	...	...	...	...	...	...	251
Delaware, Lackawanna & Western	3	462	465	...	...	...	...	...	...	...	...	465
Denver, Northwestern & Pacific	...	...	...	127	...	127	...	...	...	...	...	127
Denver, Enid & Gulf	...	...	2·8	...	...	...	...	...	...	...	...	2·8
Duluth, South Shore & Atlantic	...	...	...	...	...	...	...	...	...	4·2	1	4·2
Erie	...	11·9	11·9	768·4	675	1,443·4	...	32·5	32·5	...	...	1,487·8
Grand Rapids & Indiana	...	...	...	...	9	9	...	...	...	...	...	9
Great Northern	2·5	1	3·5	172·5	...	172·5	...	...	...	3·5	2	179·5
Hocking Valley	...	...	...	76·9	...	76·9	...	...	...	...	...	76·9
Illinois Central	9·5	230	239·5	...	...	...	758	...	758	...	...	997·5
Interborough Rapid Transit (New York)	4·9	14·1	19	...	...	...	...	...	...	...	...	19
Intercolonial	...	...	...	1,433·5	15·1	1,448·6	...	...	...	...	...	1,448·6

Lake Shore & Michigan Southern	...	296·9	296·9	977·2	246·3	1,223·5	...	...	...	...	...	1,520·4
Lehigh Valley	31	438	469	357·7	...	357·7	...	...	...	6·2	2	832·9
Long Island	...	66·6	66·6	...	...	...	...	...	28·7	28·7	...	95·3
Maine Central	31·6	3·4	35	...	...	...	...	...	...	...	...	35
Michigan Central	...	464	464	...	...	...	...	...	...	...	...	464
Missouri, Kansas & Texas	2	17	19	...	...	...	...	...	...	...	...	19
Missouri Pacific	72·9	23·4	96·3	...	...	...	...	...	...	...	...	96·3
Mobile & Ohio	5	...	5	37	...	37	...	...	...	...	...	42
Nashville, Chattanooga & St. Louis	...	...	...	97·9	7·6	105·5	...	...	...	3·5	1	109
Newburgh & South Shore	...	...	...	3	3	6	...	...	...	...	...	6
New York & Long Branch	...	38	38	...	...	...	...	...	...	...	...	38
New York Central & Hudson River	...	140	140	1,814	356	2,170	...	440	440	...	...	2,750
New York, Chicago & St. Louis	...	...	...	499	15	514	...	...	...	...	...	514
New York, New Haven & Hartford	0·5	72	72·5	160·6	53·8	214·4	...	174·4	174·4	...	...	461·3
New York, Ontario & Western	36·7	99·7	136·4	...	...	...	1·5	...	1·5	...	...	137·9
Norfolk & Western	2	10	12	1,446	218	1,664	...	...	...	...	...	1,676
Northern Pacific	...	14·8	14·8	961·7	98·1	1,059·8	...	...	...	...	...	1,074·6
North Shore (Cal.)	...	10	10	...	...	...	...	...	...	...	...	10
Oregon Railroad & Navigation Company	200	...	200	...	...	...	...	...	...	...	...	200
Oregon Short Line	32·2	...	32·2	...	...	...	...	...	...	...	...	32·2
Pennsylvania	...	241	241	531	868	1,399	...	...	...	...	...	1,640
Pennsylvania Lines, West	23	65	88	767	1,290	2,057	14	...	14	...	...	2,159
Peoria & Pekin Union	...	1	1	...	8	8	...	...	...	...	...	9
Pere Marquette	10	...	10	23	...	23	...	...	...	...	...	33
Philadelphia & Reading	21·3	459·5	480·8	171·3	163·5	334·8	8	...	8	2·7	2	826·3
Philadelphia, Baltimore & Washington	...	31	31	...	165	165	...	...	...	...	...	196
Pittsburg & Lake Erie	...	154	154	32·9	...	32·9	...	...	...	...	...	186·9
Richmond, Fredericksburg & Potomac (including Washington Southern)	...	...	...	...	115	115	...	...	...	...	...	115
St. Joseph & Grand Island	0·3	...	0·3	...	...	...	...	...	...	...	...	0·3
St. Louis & San Francisco	25	14	39	388·1	30·5	418·6	...	...	...	4	1	461·6
San Pedro, Los Angeles & Salt Lake	1·1	...	1·1	...	...	...	...	...	...	...	...	1·1
Seaboard Air Line	...	...	...	154	...	154	...	...	...	...	...	154
Southern	...	1·7	1·7	1,072·3	77·8	1,150·1	...	...	...	...	...	1,151·8
Southern Pacific	1,107·1	108	1,215·2	20	...	20	...	...	...	101	37	1,336·1
— — (Texas & Louisiana Lines)	(3) 209·8	...	209·8	...	...	...	...	...	...	...	...	(3) 209·8
Staten Island Rapid Transit	...	8·3	8·3	...	...	...	...	...	...	...	...	8·3
South Side Elevated (Chicago)	...	9·3	9·3	...	...	...	...	...	...	...	...	9·3
Texas & New Orleans	...	...	28·5	...	...	...	...	...	...	...	...	28·5
Terminal R. R. of St. Louis	...	5·5	5·5	...	...	...	...	...	...	...	...	5·5
Union Elevated (Chicago)	1	...	1	...	...	...	...	...	...	...	...	1
Union Pacific	453·6	168	(5) 621·6	...	...	...	...	...	...	...	...	(5) 621·6
Vandalia	...	...	...	...	...	237	...	...	...	...	...	237
Wabash	...	7·2	7·2	1,965·9	78·8	2,044·7	...	...	...	...	...	2,051·9
West Jersey & Sea Shore	...	94	94	48	28	76	...	...	...	...	...	170
Wisconsin Central	...	...	...	...	6·1	6·1	...	...	...	...	...	6·1
Wheeling & Lake Erie	...	5	5	...	...	...	...	...	...	...	...	1
Total	3,544·4	5,828·5	9,421·2	31,744·6	7,794·9	39,776·5	1,097·3	722·1	1,819·4	220·8	...	51,237·9

(1) 95·7 miles under construction. — (2) One track of double track. — (3) Includes 91 miles of work proposed for 1906. — (4) On practically the whole line, comprising about 3,900 miles additional, positive block signals (manual telegraph) are maintained for passenger trains. — (5) Early in 1907 the Union Pacific will have in operation additional block signals covering 223 miles of single track and 243 miles of double track, making the total 1,087·6.

[656 .222.1]

4. — The dangers of speed.

(*Railroad Gazette.*)

In his testimony this week before the New York Railroad Commission, Mr. Newman, president of the New York Central, made two statements : 1° fast trains are furnished because the public demands them; 2° the limit of safety for fast express trains has not yet been passed. The first of these statements is unquestionable. The experience of the 18-hour trains between Chicago and New York proves that enough people to fill those trains want to travel at the speed, and also that this fast traffic is increased traffic, inasmuch as the loading of the other trains has not been materially lessened. The passenger movement by the *Empire State Express* was, from the beginning in 1891, found to be almost entirely in addition to the then passenger movement on the road. Voluntary competition in speed, for any considerable period, is unusual. It is more apt to take the form of increases in comfort and luxury, as in the admirable trains of six competing lines between Chicago and St. Paul.

The second statement, that the limit of safe speed has not been passed, needs examination. The record of some high-speed scheduled trains seems to corroborate it.

On October 26, 1891, the *Empire State Express* began running on regular schedule between New York and Buffalo at an average rate of speed, including four stops, of over 52 miles an hour. For fifteen years and four months, this train has performed this fast service each week day with unusual punctuality. The average speed has been increased to 53·3 miles per hour, which involves a daily running over considerable stretches at more than 70 miles an hour, and the speed is said to have been at times 100 miles an hour. In the past 4,800 week days, the two east and west expresses have run 4 $^1/_4$ million miles with no serious accident involving the loss of a passenger's life.

On the Great Western Railway, in England, between London and Bristol, over 118 miles, daily trains each way have been running for many years, covering the distance in two hours, with an average speed, including one rather long stop, of 59·2 miles per hour. No serious accident has occurred.

In looking over the record of high-speed scheduled trains, we find fatal accidents, but it is necessary to examine further and find whether or not the speed was a factor in causing those accidents. The two fastest scheduled trains in the world are the Pennsylvania's and the Reading's Camden and Atlantic City trains, the first of which is timed for a speed of 68·1 miles per hour for a distance of 59 miles, and the second a speed of 66·6 miles per hour for 55 $^1/_2$ miles. These trains have not been exempt from fatal accidents, but with one exception there have not been great accidents and that one was not due to fast running — either that fast running due to the schedule or to a violation of orders. The most serious accident occured on July 30, 1896, when the engineman of the Reading train disregarded his signal at a grade crossing of the Pennsylvania's line. Due to this negligence, and probably not even indirectly due to his speed, his train collided with a slow Pennsylvania Railroad train at that crossing, and killed 47 people on the slow train. No passenger on the fast train was killed.

During the Chicago Exposition year, 1893, the *Columbian Express* made its daily 20-hour trips between New York and Chicago, over the New York Central and the Lake Shore, without serious accident. This cannot be said of 18-hour trains running for nearly two years on both the New York Central and the Pennsylvania. On June 21, 1905, the New York Central's train ran through an open switch at Mentor and 15 passengers were killed. The speed of the train had nothing to do with the cause of this derailment; it would have occurred at a speed of between 30 and 40 miles an hour, although it is undoubtedly true that the destructive effects on the train after the derailment, and probably the number of passengers killed, were greatly increased because of the high speed. These destructive effects increase as the square of the speed.

It should be borne in mind that scheduled high-speed trains have been made as safe as they appear to have been only made by reason of extra care and watchfulness in their running, by the use of cars of strong construction, vestibuled throughout, and also by running them on tracks set apart in most cases for passenger service. It is recognized by all railroad officers that these are the only conditions under which fast service can be maintained safely.

Nevertheless, the prevailing opinion that fast running is the cause of many wrecks and losses of life is fully substantiated. For example, a newspaper train on the New York Central was derailed near Little Falls, N. Y., on a 7° curve solely because of excessive speed. Two were killed and one was injured. A passenger train on the Wabash, at St. Louis, was derailed on a 10° curve. As the speed was estimated at 60 miles an hour, there can be no question as to the cause. One was killed and 43 were injured. A mail train on the Pennsylvania was derailed on a 7° curve at an estimated speed of 66 miles an hour, and no further investigation of the cause was needed. Two were killed and four injured. It has, however, a sobering effect on any attempt at quick judgment to consider two recent derailments, one on the Louisville & Nashville at a speed of 12 miles an hour where nine people were killed, and another a derailment on a bridge where the speed was 60 miles per hour and none were killed.

The official reports of the Interstate Commerce Commission since June 30, 1906, are not yet available, but an examination of a reasonably correct record during the past three months furnishes some lessons. Of 64 serious accidents in November last, 25 were caused by passenger trains, and 39 by those classed as freight trains. There were two high-speed accidents, but neither of them was a high-speed scheduled train. Of the 52 serious accidents reported for December of last year, 28 were caused by passenger trains and 24 by those classed as freight. One of these accidents, which occurred in a fog, was undoubtedly due to the speed being beyond the control of the engineman, but it occurred under the unsafe permissive system of using block signals. In 45 serious accidents in January, 123 persons were killed. Twenty-three of these accidents were collisions and caused the loss of 80 lives; one was due to a dynamite explosion which killed 16 persons : another due to a boiler explosion which killed five persons. We do not find indication of any of these accidents being caused by high speed; nevertheless, this is not conclusive; the causes have not all been reported.

We arrive then at only a partial conclusion. High-speed running has been made reasonably safe under a certain set of conditions. It is unsafe unless the track and train are strong enough, unless the track is devoted exclusively to passenger service, or the way is entirely cleared by special order. There are other absolute requirements : the high speed brake is essential. The distant and home signals must be so placed as to allow the engineman to control and stop his train within the required distance under all weather conditions. Of course, every turnout and drawbridge must be interlocked with the signals. This is not a complete enumeration of the physical conditions necessary for fast running, but any competent railroad officer can complete the list.

The final essential condition — effective discipline and uniform obedience to orders by the trainmen and trackmen — can never be secured. The ideal can be approximated. It is a general prevailing opinion among railroad officers that in this country we are now not approximaling the ideal; we are retrograding. A lack of zeal and fidelity among railroad employees seems to be growing. The cause of this is, to some extent, a psychological study. Perhaps it is in part due to the prevailing prosperity, which unsettles the minds of many otherwise contented men, perhaps it is partly due to the open encouragement, by those in high governmental authority, of the trade unions and the increasing development of the most vicious elements in the trade union idea. This study would be interesting, but for the moment it is unprofitable. Whatever may be the cause of the present deterioration in disciplne, the present duty of railroad officers to get and maintain better discipline is plain.

MONTHLY BIBLIOGRAPHY OF RAILWAYS (1)

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L. WEISSENBRUCH,
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[016 .385. (02]

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(March, 1907.)

In French.

1907 — **62**. (01

AERTS (Louis), ingénieur, professeur à l'athénée royal et directeur de l'école industrielle de Louvain.

Éléments pratiques de la résistance des matériaux, à l'usage des ingénieurs, conducteurs, architectes, etc.

Paris, Béranger, éditeur. 3e édition, 1 volume in-8°, 203 figures dans le texte. (Prix : 8 francs.)

1906 — **62**. (02

CLAUDEL (J.), ingénieur des arts et manufactures.

Aide-mémoire des ingénieurs, architectes, entrepreneurs, conducteurs, agents-voyers, dessinateurs, etc. — 11e édition revue et augmentée par un comité d'ingénieurs et de professeurs, sous la direction de G. Dariès, ingénieur de la ville de Paris. — Partie pratique : formules, tables et renseignements usuels.

Paris, Dunod & Pinat. T. 1er, in-8°, 1,112 pages, 612 figures. (Prix, 2 volumes-ouvrage complet : 30 francs.)

1906 — **385**. (01 (.675)

FÉDÉRATION POUR LA DÉFENSE DES INTÉRÊTS BELGES A L'ÉTRANGER.

Vers la suppression du portage. Le chemin de fer du Congo supérieur de Stanleyville à Ponthierville.

Bruxelles, Imprimerie des travaux publics. In-8°, 58 pages, gravures et 3 cartes hors texte.

1907 — **69**

FUGAIRON (Jean), architecte.

Recueil de procédés pratiques à l'usage du bâtiment.

Paris, Dunod & Pinat. 1 volume in-8°, VI-604 pages et figures. (Prix : 25 francs.)

1906 — **625** .14 (01

MARIÉ (G.), ingénieur, chef de division de la Compagnie Paris-Lyon-Méditerranée, en retraite.

Les dénivellations de la voie et les oscillations du matériel des chemins de fer.

Paris, Dunod & Pinat, éditeurs. In-8°, XVI-142 pages 26 figures. (Prix : 4 francs.)

1906 — **625** .215. (01

MARIÉ (G.), ingénieur, chef de division de la Compagnie Paris-Lyon-Méditerranée, en retraite.

Les oscillations du matériel des chemins de fer à l'entrée en courbe et à la sortie.

Paris, Dunod & Pinat, éditeurs. In-8°, 50 pages, 10 figures. (Prix : 2 francs.)

1906 — **625** .14 (01 & **625** .2 (01

MARIÉ (G.), ingénieur, chef de division de la Compagnie Paris-Lyon-Méditerranée, en retraite.

Les oscillations du matériel et la voie.

Paris, Dunod & Pinat, éditeurs. In-8°, 68 pages, 10 figures. (Prix : 2 francs.)

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(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjoinly with the Office Bibliographique International, of Brussels. (See "Bibliographical Decimal Classification as applied to Railway Science," by L. Weissenbruch, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

N. B. — The Monthly Bibliography is printed on one side only so that it may be cut up into slips and pasted on labels for catalogues and indexes.

1907 **621** .9 (01

MERLOT (Jules), ingénieur-mécanicien, répétiteur du cours de construction des machines et chef des travaux d'atelier à la Faculté technique de l'université de Liége.

Principes de la construction des machines-outils.

Paris, Béranger, éditeur. 1 volume in-8°, 987 figures dans le texte. (Prix : 40 francs.)

1907 **691**. (01

MINISTÈRE DES TRAVAUX PUBLICS, DES POSTES ET DES TÉLÉGRAPHES DE FRANCE.

Commission du ciment armé. Expériences, rapports et propositions, instructions ministérielles relatives à l'emploi du béton armé.

Paris, Dunod & Pinat, éditeurs. In-4°, 482 pages, figures et 8 planches. (Prix : 27 fr. 50 c.)

1907 **621** .14 (09.3

SOUVESTRE (P.).

Histoire de l'automobile.

Paris, Dunod & Pinat, éditeurs. In-8°, 800 pages avec figures. (Prix : 15 francs.)

1906 **385** .15

WICKERSHEIMER (E.), ingénieur en chef des mines.

A propos du rachat du chemin de fer de l'Ouest : industries d'État, administrations privées.

Paris, Dunod & Pinat, éditeurs. In-8°, 40 pages. (Prix : 2 francs.)

In German.

1907 **385** .1

ACWORTH (W. M.).

Grundzüge der Eisenbahnwirtschaftslehre. Aus dem Englischen übersetzt nebst einleitendem Vorworte von Dr. Heinrich Ritter v. WITTEK, Geheimer Rat, k. k. Minister a. D.

Wien, Manz'sche Buchhandlung.

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Flister's Eisenbahn-Kalender für das Jahr 1907.

Berlin, Dr. A. Tetzlaff. 24. Jahrgang, in-8°, VIII-420 Seiten mit Abbildungen und 1 Bildnis. (Preis : 1.25 Mark.)

1907 **347** .2

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Die Eisenbahnen im Kriege. Eine völkerrechtliche Studie.

Zürich, Buchdruckerei Jean Frank.

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STRUKEL (M.).

Der Brückenbau, nach den Vorträgen, gehalten am Finnländischen Polytechnischen Institut in Helsingfors. II. Teil : **Bewegliche und steinerne Brücken.**

Leipzig, A. Twietmeyer. 41 Taf., Quellenangaben und kurzer Erläuterung der Abbildungen. (Preis : 10 Mark.)

In English.

1907 **621** .31

BAXTER Jr. (W.).

Switchboards for power, light and railway service, direct and alternating current, high and low tension.

New York, Derry-Collard Co. 8vo, I + 7-192 pages, ill. diagrams. (Price : $1.50.)

1907 **385** .14

BEALE Jr. (Joseph Henry) & **WYMAN** (Bruce).

The law of railroad rate regulation, with special reference to American legislation.

Boston, William J. Nagel. Buckram, 12mo, 1,285 pages.

1907 **621** .116 & **621** .133.7

CHRISTIE (W. W.).

Boiler-waters : scale, corrosion, foaming.

New York, D. Van Nostrand Co. 8vo, 7 + 235 pages, 77 illustrations. (Price : $3.)

1907 **621** .134.3 (02 & **621** .134.4 (02

GAIRNS (J. F.).

Locomotive compounding and superheating. A practical text-book for the use of railway and locomotive engineers, students and draughtsmen.

London, Charles Griffin & Co. 8vo, 189 pages fully illustrated. (Price : 8*s.* 6*d.*)

1907 **621** .33 (02

GANT (L. W.).

Elements of electric traction. For motormen and others.

London, Harper. 8vo (8 3/4 × 5 1/2 inches), 228 pages. (Price : 5*s.*)

1907 **62**. (03

GARCIA (A. J. R. V.).

Dictionary of engineering terms in English and Spanish, with index in both languages; containing 3,000 technical terms.

New York, Spon & Chamberlain. 12mo. (Price : $1.)

1907 **621** .131.3

GOSS (W. F. M.).

Locomotive performance : a result of a series of researches conducted by the engineering laboratory of Purdue University.

New York, John Wiley & Sons. 8vo, 16 + 439 pages, 229 figures. (Price : $5.)

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Modern steam engineering in theory and practice.

London, Lockwood. 8vo (9 1/4 × 6 inches), 488 pages, illustrations. (Price : 12*s.* 6*d.*)

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KEMPE (H. R.).

Engineer's year-book of formulae, rules, tables, data, and memoranda in civil, mechanical, electrical, marine, and mine engineering for 1907.

London, Lockwood. 8^{vo} (7 1/4 × 4 3/4 inches), 1,028 pages, 1,000 illustrations. (Price : 8*s.*)

1907 **721** .4

LEFFLER (Burton R.), engineer of bridges, Lake Shore & Michigan Southern Railway.

The elastic arch; with special reference to the re-enforced concrete arch.

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Locomotive engineer's pocket-book and diary, 1907.

London, Locomotive publishing Co. 18mo, limp. (Price : 1*s.*)

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Proceedings for the year 1906. Meeting held at New York.

Bethlehem, Pa., published by the Association. 8vo, 342 pages.

1907 **669.** (02

SCHNABEL (Carl).

Handbook of metallurgy. Translated by Henry Louis.

London, Macmillan. Vol. 2, second edition, 8vo (9 × 6 inches), 884 pages. (Price : 21*s.*)

1907 **669** .1

WEST (T. D.).

Metallurgy of cast iron.

London, A. F. Bird. Eleventh edition, 8vo. (Price : 12*s.* 6*d.*)

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SCHLÜSSEL (L.). — Note sur le renouvellement et l'entretien économiques des voies de chemins de fer capables de grandes vitesses. (12,700 mots, 1 tableau & fig.)

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UYTBORCK (Em.). — Locomotive mixte des chemins de fer de l'État belge pour la manœuvre des wagons à marchandises. (3,200 mots & fig.)

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COLSON (C.). — La navigation intérieure en 1905. (Revue des questions de transports.) (5,700 mots & 1 tableau.)

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Bulletin du Congrès des chemins de fer, nº 2, février, p. 179.

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Services par automobiles (question XX, 7ᵉ session). Discussion. (10,200 mots & fig.)

1907 **656** .254
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BURDICK (H. L.) & SAUNDERS (W. T.). — Le téléphone dans le service des chemins de fer. (1,400 mots.)

1907 **625** .253
Bulletin du Congrès des chemins de fer, nº 2, février, p. 224.

Le fonctionnement de la triple valve « K » indiqué par des schémas. (950 mots & fig.)

1907 **625** .251
Bulletin du Congrès des chemins de fer, nº 2, février, p. 228.

Un cas d'obstruction de la conduite générale du frein à air. (300 mots.)

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Pourcentage des wagons à marchandises équipés au frein continu aux États-Unis. (350 mots.)

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Bibliographie mensuelle des chemins de fer. — Livres. (34 fiches.)

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MAZEN (N.). — La traction électrique appliquée aux chemins de fer. (10,000 mots & fig.)

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L'interrupteur électrique pour signaux ne fonctionnant que dans un seul sens. (500 mots & fig.)

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Génie civil, nº 1289, 23 février, p. 288.

Tramway électrique avec rampe à contrepoids de Sydney (Australie). (1,100 mots & fig.)

Nouvelles annales de la construction. (Paris.)

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CHAUDESAIGUES. — Méthode de calcul des pièces et système en ciment armé. (2,800 mots & fig.)

Portefeuille économique des machines. (Paris.)

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MORIZOT (A.). — Locomotives de grande banlieue, à deux bogies, de la Compagnie du chemin de fer du Nord. (2,000 mots & fig.)

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DESCUBES. — Note sur les voies américaines. (3,400 mots, 2 tableaux & fig.)

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HALLARD. — Note sur l'application du chauffage des trains par la vapeur, système Heintz, sur le réseau des chemins de fer du Midi. (2,400 mots & fig.)

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Appareil servant à mesurer l'usure des rails. (800 mots & fig.)

1907 **621** .132.5
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Locomotive Mallet à 8 essieux couplés en deux groupes. (350 mots & fig.)

1907 **625** .241
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Wagon de 100 tonnes. (100 mots & fig.)

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1907 **621** .135.2
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1907 **621** .97
Revue de mécanique, nº 1, janvier, p. 5.

BARIL (A.). — Note sur les frappeurs pneumatiques. (4,500 mots, 2 tableaux & fig.)

1907 **621** .95
Revue de mécanique, nº 1, janvier, p. 21.

CODRON (C.). — Expériences sur le travail des machines-outils. (6,500 mots & fig.)

In German.

Bulletin des internationalen Eisenbahn-Kongress-Verbandes. (Brüssel.)

1907 **621** .132.3 (.489)
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 105.

BUSSE (O.). — Schnellzuglokomotive mit vier Cylindern für die dänischen Staatsbahnen. (1,400 Wörter, 1 Tabelle & Abb.)

1907 **656** .259
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 114.

MAAS-GEESTERANUS (H. P.). — Ein neuer Apparat zur Ueberwachung der Geschwindigkeit von Eisenbahnzügen. (1,500 Wörter & Abb.)

1907 **621** .134.3
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 120.

Dampfüberhitzung bei der Canadian-Pacificbahn. (3,800 Wörter & 3 Tabellen.)

1907 **551** .51 & **621** .39
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 129.

GOLDSCHMIDT (R.). — Ein elektrischer Windmesser. (1,150 Wörter & Abb.)

1907 **531** .87
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 134.

MINNE (André). — Untersuchungen über Schraubensicherungen und die selbsttätige Lösung der Schraubenmuttern. (1,350 Wörter & Abb.)

1907 **621** .132.8
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 138.

HILD (F. W.). — Der Gasolinwagen im Ortsverkehr. (3,800 Wörter, 3 Tabellen & Abb.)

1907 **625** .61 (.42)
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 148.

GLENDENNING (Seymour). — Die Kleinbahn zwischen Burton und Ashby. (2,200 Wörter & Abb.)

1907 **725** .31
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 155.

Die Weiterführung der Pennsylvania-Eisenbahn nach New-York und Long Island. (1,600 Wörter & Abb.)

1907 **385** .57
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 162.

ARTHURTON (Alfred W.). — Ausbildung der Eisenbahnbediensteten. Die « Great Western Railway Lecture and Debating Society ». (3,200 Wörter.)

1907 **621** .132.5
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 168.

Doppel-Verbund-Güterzug-Locomotive, System Mallet, der « Great Northern Railway » (Vereinigten Staaten). (1,500 Wörter & Abb.)

1907 **625** .242
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 173.

30-Tonnen-Wagen der « North-Eastern Railway » für die Beförderung von Eisenerz. (1,800 Wörter & Abb.)

1907 **625** .216
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 179.

Die Cardwell'sche Friktionszugvorrichtung und seitliche Pendelstütze. (750 Wörter & Abb.)

1907 **625** .253
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 182.

Prozentverhältnis der in den Vereinigten Staaten mit Luftdruckbremse ausgerüsteten Güterwagen. (250 Wörter.)

1907 **625** .143.1 & **625** .143.5
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 182.

Eine Schiene die nicht wandert. (500 Wörter & Abb.)

1907 **656** .281
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 184.

Der Unfall bei Grantham. (3,400 Wörter & Abb.)

1907 **54**
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 192.

Der Streit über das Radium. (2,200 Wörter.)

1907 **016** .385. (02
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 17.

Monatliches Verzeichnis der Eisenbahnliteratur. — Bücher. (34 Zettel.)

1907 **016** .385. (05
Bulletin des Eisenbahn-Kongresses, Nr 2, Februar, S. 20.

Monatliches Verzeichnis der Eisenbahnliteratur. — Zeitschriften. (185 Zettel.)

Œsterreichische Eisenbahn-Zeitung. (Wien.)

1907 **656** .256.3 & **625** .4

Œsterreichische Eisenbahn-Zeit., Nr 5, 4. Februar, p. 37.

KOHLFÜRST (L.). — Die Zugsicherungseinrichtungen der Londoner Distriktsbahnlinien. (1,600 Wörter & Abb.) (S. *Bulletin du Congrès des chemins de fer*, n° 12, décembre 1906.)

1907 **385** .517.6

Œsterreichische Eisenbahn-Zeit., Nr 5, 4. Februar, p. 40.

BÉKÉSS (A.). — Ueber Seh- und Farbenprüfung im Eisenbahndienst. (1,500 Wörter.)

1907 **656** .2 (01

Œsterreichische Eisenbahn-Zeit., Nr 8, 25. Februar, p. 69.

HILSCHER (F.). — Neugestaltung des Eisenbahn-Betriebsreglements. (2,100 Wörter.)

Elektrische Bahnen und Betriebe. Zeitschrift für Verkehrs- und Transportwesen.

(München.)

1907 **621** .331

Elektrische Bahnen u. Betriebe, Heft 4, 4. Februar, p. 61.

KÖSTER (F.). — Das Kraftwerk Pennsylvania in Long Island-City der Pennsylvania, New York and Long Island Railroad Company. (3,200 Wörter & Abb.

1907 **621** .333

Elektrische Bahnen u. Betriebe, Heft 4, 4. Februar, p. 68.

REICHEL (W.). — Bahnmotor von 350 PS-Stundenleistung für einphasigen Wechselstrom von 25 Pulsen. (2,500 Wörter, 1 Tabelle & Abb.)

1907 **621** .335

Elektrische Bahnen u. Betriebe, Heft 6, 23. Februar, p. 101.

VALATIN (B.). — Drehstromlokomotiven mit drei Geschwindigkeitsstufen der italienischen Staatsbahnen. (1,800 Wörter & Abb.)

Zeitschrift des österreichischen Ingenieur- und Architekten-Vereines. (Wien.)

1907 **621** .33

Zeit. des öst. Ingen.- und Archit.-Ver., Nr 7, 15. Februar, p. 109.

CSERHÁTI (E.). — Der elektrische Betrieb auf Vollbahnen vom wirtschaftlichen und strategischen Standpunkte. (6,000 Wörter & Abb.)

Zeitschrift für Kleinbahnen. (Berlin.)

1907 **313** : **625** .61 (.43)

Zeitschrift für Kleinbahnen, Heft 2, Februar, p. 57.

Statistik der Kleinbahnen im Deutschen Reiche für das Jahr 1905. (2,500 Wörter & Tabellen.)

1907 **313** : **625** .62 (.44)

Zeitschrift für Kleinbahnen, Heft 2, Februar, p. 85.

Die Strassenbahnen in Frankreich im Jahre 1903. (300 Wörter & Tabellen.)

Zeitschrift des Vereines deutscher Ingenieure.

(Berlin.)

1907 **621** .33

Zeitsch. des Vereines deutscher Ingen., Nr 5, 2. Februar, p. 161.

ZWEILING (A.). — Die elektrischen Bahnen auf der Ausstellung in Mailand 1906. (3,200 Wörter & Abb.)

1907 **385**. (01 (.67) & **625** .611 (.67)

Zeitsch. des Vereines deutscher Ingen., Nr 6, 9. Februar, p. 201.
— — Nr 8, 23. — p. 281.

WECHSLER (M.). — Die Otavi-Bahn. (6,200 Wörter, 3 Tabellen & Abb.)

1907 **621** .33 & **625** .13

Zeitsch. des Vereines deutscher Ingen., Nr 6, 9. Februar, p. 213.

RUPP (H.). — Der elektrische Betrieb der Simplon-Bahn. (2,800 Wörter & Abb.)

1907 **625** .142.3 (.73)

Zeitsch. des Vereines deutscher Ingen., Nr 7, 16. Februar, p. 259.

MÜLLENHOFF (K. A.). — Versuche mit flusseisernen Querschwellen in den Vereinigten Staaten von Nordamerika. (1,200 Wörter & Abb.)

1907 **621** .138.2

Zeitsch. des Vereines deutscher Ingen., Nr 8, 23. Februar, p. 292.

GUILLERY (C.). — Bekohlanlage mit Greifer auf dem Bahnhof Köln (Eifeltor). (1,400 Wörter & Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1907 **656** .22 (.43)

Zeitung des Vereins, Nr 9, 2. Februar, p. 137.

BLUM. — Einheitliche Fahrdienstvorschriften für die deutschen Eisenbahnen. (1,200 Wörter.)

1907 **656** .256.3 & **625** .4

Zeitung des Vereins, Nr 10, 6. Februar, p. 153.

KOHLFÜRST (L.). — Das Zugmeldeverfahren der Londoner Untergrundbahnen. (2,500 Wörter & 1 Tabelle.) (S. *Bulletin du Congrès des chemins de fer*, n° 12, décembre 1906.)

1907 **625** .13
Zeitung des Vereins, Nr 13, 16. Februar, p. 203.

SCHULZE (W. A.). — Die Untertunnelung des Armelkanals in ihrer Bedeutung für die verschiedenen Reisewege zwischen England und dem europäischen Festlande. (2,000 Wörter.)

1907 **656** .25 (01 (.73)
Zeitung des Vereins, Nr 15, 23. Februar, p. 231.
— Nr 16, 27. — p. 247.

BLUM. — Einiges über die Sicherungsanlagen der amerikanischen Eisenbahnen. (3,400 Wörter & Abb.)

Zentralblatt der Bauverwaltung. (Berlin.)

1907 **625** .144.2
Zentralblatt der Bauverwaltung, Nr 12, 6. Februar, p. 83.

BRÄUNING (C.). — Ueber Gleisbogen. (2,600 Wörter & Abb.)

In English.

American Engineer and Railroad Journal. (New York.)

1907 **621** .338 & **625** .232
American Engineer & R. Journal, No. 2, February, p. 41.

Steel passenger car. Long Island Railroad. (1,800 words & fig.)

Bulletin of the International Railway Congress Association. (Brussels.)

1907 **621** .132.3 (.489)
Bulletin of the Railway Congress, No. 2, February, p. 143.

BUSSE (O.). — The four-cylinder express locomotives of the Danish State Railway. (1,650 words, 1 table & fig.)

1907 **531** .87
Bulletin of the Railway Congress, No. 2, February, p. 152.

MINNE (André). — Note on the working loose of nuts. (1,350 words & fig.)

1907 **621** .33
Bulletin of the Railway Congress, No. 2, February, p. 155.

MÜLLER (W. A.). — The electric railways and tramways of Switzerland. (7,800 words, 5 tables & fig.)

1907 **621** .138.3
Bulletin of the Railway Congress, No. 2, February, p. 180.

ROESCH (F. P.). — The care of locomotive boilers at terminals and while in service. (2,800 words.)

1907 **621** .131.1
Bulletin of the Railway Congress, No. 2, February, p. 185.

RAYMOND (William G.). — Acceleration, and some locomotive problems. (4,500 words.)

1907 **625** .61 (01
Bulletin of the Railway Congress, No. 2, February, p. 197.

Influence of light railways on the main lines (question XVII, 7th session). Discussion. (5,400 words.)

1907 **625** .611
Bulletin of the Railway Congress, No. 2, February, p. 211.

Direct financial co-operation by the State and by localities interested in the development of light railways. (16,800 words.)

1907 **625** .143.4
Bulletin of the Railway Congress, No. 2, February, p. 248.

The double sleeper joint and the creeping of rails. (3,000 words, 1 table & fig.)

1907 **621** .132.3
Bulletin of the Railway Congress, No. 2, February, p. 254.

Prairie type compound engines at Milan Exhibition. (1,000 words & fig.)

1907 **625** .233
Bulletin of the Railway Congress, No. 2, February, p. 256.

Acetylene car lighting on Great Northern Railway (United States). (1,000 words & fig.)

1907 **313** : **625** .14
Bulletin of the Railway Congress, No. 2, February, p. 260.

Cross-ties used by railroads in the United States in 1905. (600 words & 3 tables.)

1907 **656** .281
Bulletin of the Railway Congress, No. 2, February, p. 263.

The Atlantic City Accident. (1,450 words.)

1907 **385**. (09.2
Bulletin of the Railway Congress, No. 2, February, p. 266.

Obituary : Alexander Johnston CASSATT. (1,650 words & portrait.)

1907 **016** .385. (02
Bulletin of the Railway Congress, No. 2, February, p. 17.

Monthly bibliography of railways. — Books. (34 labels.)

1907 **016** .385. (05
Bulletin of the Railway Congress, No. 2, February, p. 20.

Monthly bibliography of railways. — Periodicals. (185 labels.)

Engineer. (London.)

1907 **388** (.73)
Engineer, No. 2666, February 1, p. 108.
— No. 2667, — 8, p. 128.
Transit facilities in New York. (7,200 words & fig.)

1907 **656** 212.6
Engineer, No. 2666, February 1, p. 118.
A 150-ton giant crane. (2,400 words, 1 table & fig.)

1907 **624** .61
Engineer, No. 2667, February 8, p. 130.
New stone bridge at Orleans. (3,000 words, 2 tables & fig.)

1907 **621** .131
Engineer, No. 2667, February 8, p. 139.
Locomotive economy. (1,000 words.)

1907 **621** .132.3
Engineer, No. 2669, February 22, p. 186.
Four-cylinder non compound engine : Great Western Railway. (175 words & fig.)

Engineering. (London.)

1907 **621** .132.3
Engineering, No. 2144, February 1, p. 144.
Six-coupled passenger express locomotive: Caledonian Railway. (900 words, 1 table & fig.)

1907 **621** .14
Engineering, No. 2145, February 8, p. 181.
Motor-omnibuses. (2,100 words.)

1907 **388**
Engineering, No. 2145, February 8, p. 193.
MACASSEY (L.). — Urban and suburban traffic. 4,400 words & 2 tables.)

1907 **625** .144.4
Engineering, No. 2146, February 15, p. 208.
The Moore track-drill. (500 words & fig.)

1907 **621** .112
Engineering, No. 2147, February 22, p. 227.
The specific heat of superheated steam. (1,300 words, tables & fig.)

1907 **624** .32
Engineering, No. 2147, February 22, p. 229.
Khushalgarh bridge. (900 words & fig.)

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1907 **625** .241
Engineering, No. 2147, February 22, p. 239.
Double-bogie wagon for carrying rails; Glasgow and South Western Railway. (250 words & fig.)

1907 **656** .212.6
Engineering, No. 2147, February 22, p. 250.
150-ton hydraulic wharf-crane at Elswick. (350 words & fig.)

Engineering News. (New York.)

1907 **624** .63
Engineering News, No. 5, January 31, p. 117.
The Walnut lane concrete arch bridge across the Wissahickon, Philadelphia. (1,600 words & fig.)

1907 **625** .12
Engineering News, No. 5, January 31, p. 120.
New standard roadway on the Pennsylvania Railroad. (400 words & fig.)

1907 **388** & **625** .4
Engineering News, No. 5, January 31, p. 122.
STRAUSS (J. B.). — The Union loop of Chicago and a proposed terminal station system for the elevated railways of Chicago. (3,300 words & fig.)

1907 **656** .212
Engineering News, No. 6, February 7, p. 158.
NORTH (H. M.). — The design of railway freight terminals. (4,800 words & fig.)

1907 **624** .62
Engineering News, No. 7, February 14, p. 171.
CONSTANT (F. H.). — Strengthening the three-hinged arch bridge over the Mississipi River between Minneapolis and St. Paul, Minn. (3,400 words & fig.)

1907 **624** .63
Engineering News, No. 7, February 14, p. 178.
Competitive designs for a reinforced-concrete viaduct in Milwaukee, Wis. (3,200 words & fig.)

1907 **625** .14 (01
Engineering News, No. 7, February 14, p. 186.
SELBY (O. E.). — A design for railway track, based upon a study of the stresses existing in track superstructure. (2,400 words & fig.)

Great Western Railway Magazine. (London.)

1907 **625** .13
Great Western Railway Magazine, No. 2, February, p. 29.

MATTHEWS (E. C.). — Improvements of the main line in Cornwall. (2,000 words & fig.)

Institution of Mechanical Engineers. (London.)

1906 **656** .212.6
Institution of Mechanical Engineers, No. 3, July, p. 403.

REE (H. S. C.). — Mechanical appliances used in the shipping of coal at the bute docks, Cardiff. (4,700 words, 1 table & fig.)

1906 **656** .212.6
Institution of Mechanical Engineers, No. 3, July, p. 423.

RICHES (H.) & HEYWOOD (T. E.). — Mechanical appliances used in the shipping of coal at Penarth dock. (1,800 words & fig.)

1906 **656** .212.6
Institution of Mechanical Engineers, No. 3, July, p. 435.

MACAULAY (J.). — Coal-shipping appliances and hydraulic power-plant at the Alexandra (Newport and South Wales) docks and railway, Newport, Mon. (18,000 words, tables & fig.)

Journal of the Franklin Institute. (Philadelphia.)

1907 **625** .212
Journal of the Franklin Institute, No. 1, January, p. 1.

LOSS (H. V. von Z.). — The art of manufacture of railway car axles. (7,000 words & fig.)

Journal of the West of Scotland Iron and Steel Institute. (Glasgow.)

1906 **669** .1
Journ. of the West of Scotl. I. & St. Inst., No. 2, November, p.38.

ADAMSON (E.). — Cast iron. (7,000 words, tables & fig.)

Locomotive Firemen and Enginemen's Magazine. (Indianapolis.)

1907 **621** .134.2
Locom. Firemen and Enginemen's Magazine, February, p. 207.

WOOD (W. W.). — Questions and answers on the Walschaerts valve gear. (5,600 words & fig.)

Locomotive Magazine. (London.)

1907 **625** .254
Locomotive Magazine, No. 174, February 5, p. 28.

Rapid-acting vacuum brake. (350 words & fig.)

Page's Weekly. (London.)

1907 **625** .13
Page's Weekly, No. 128, February 22, p. 400.

The Channel tunnel scheme. (2,200 words & fig.)

Railroad Gazette. (New York.)

1907 **313** .385. (01 (.42 + .73)
Railroad Gazette, No. 5, February 1, p. 132.

Comparative use of working statistics in two countries. (1,700 words.)

1907 **621** .33
Railroad Gazette, No. 5, February 1, p. 134.

Substitution of the electric motor for the steam locomotive. (3,600 words.)

1907 **656** .223.2
Railroad Gazette, No. 5, February 1, p. 136.

HUTCHINS (F. L.). — A new method of car recording at local stations. (4,200 words & fig.)

1907 **621** .132.3
Railroad Gazette, No. 5, February 1, p. 140.

Balanced Pacific type locomotive for the National of Mexico. (500 words & fig.)

1907 **313** .385 (.42 + .73)
Railroad Gazette, No. 5, February 1, p. 142.

Watching freight traffic by daily returns. (3,000 words.)

1907 **621** .132.3
Railroad Gazette, No. 5, February 1, p. 147.

Four-cylinder compound locomotive for the Italian State Railroads. (2,000 words & fig.)

1907 **621** .132.8
Railroad Gazette, No. 6, February 8, p. 169.

A German motor car. (550 words & fig.)

1907 **621** .33 & **625** .13
Railroad Gazette, No. 6, February 8, p. 170.

Electric operation of the Simplon tunnel. (300 words & fig.)

1907 **625 .13**
Railroad Gazette, No. 6, February 8, p. 174.

New Lehigh Valley bridge over the Susquehanna River, near Towanda, Pa. (900 words & fig.)

1907 **621 .134.3**
Railroad Gazette, No. 6, February 8, p. 181.

COLE (F. J.). — Locomotive superheaters. (2,300 words, 1 table & fig.)

1907 **313 : 656 .28 (.73)**
Railroad Gazette, No. 7, February 15, p. 209.

Government accident bulletin No. 21. (1,200 words & 3 tables.)

Railway Age. (Chicago.)

1907 **621 .33**
Railway Age, No. 1599, February 1, p. 142.

STILLWELL (L. B.) & ST. CLAIR PUTNAM (H.). — The substitution of the electric motor for the steam locomotive. (13,000 words, 3 tables & fig.)

Railway Engineer. (London.)

1907 **656 .257**
ailway Engineer, No. 325, February, p. 43.

Signalling at Crewe. (1,100 words & fig.)

1907 **621 .133.3**
ailway Engineer, No. 325, February, p. 53.

Locomotive boilers with wide fire-boxes. (1,300 words & fig.)

1907 **621 .138.3**
ailway Engineer, No. 325, February, p. 58.

WILLIAMS (J.) & HODGSON (J. T.). — The locomo- ve from cleaning to driving. (2,600 words & fig.)

Railway and Engineering Review. (Chicago.)

1907 **656 .212. (01**
ailway and Engineering Review, No. 4, January 26, p. 65.

Theory of design of railway freight terminals. ,200 words, 1 table & fig.)

A.

1907 **621 .132.5 & 621 .134.3**
Railway and Engineering Review, No. 5, February 2, p. 82.

Superheating on the A. T. & S. F. Ry. (900 words, 1 table & fig.)

1907 **625 .151**
Railway and Engineering Review, No. 5, February 2, p. 86.

Device to automatically close facing switches. (350 words & fig.)

1907 **656 .223.2**
Railway and Engineering Review, No. 6, February 9, p. 105.

Some phases of the car shortage situation. (1,700 words.)

1907 **621 .33**
Railway and Engineering Review, No. 6, February 9, p. 110.

Substitution of electric motors for steam locomotives. (4,500 words.)

Railway Gazette. (London.)

1907 **621 .132.3**
Railway Gazette, No. 6, February 8, p. 130.

Egyptian State 4-4-0 type passenger locomotive, with feed-water heater. (1,400 words, 1 table & fig.)

1907 **621 .134.3**
Railway Gazette, No. 8, February 22, p. 181.

COLE (F. J.). — Locomotive superheaters. (2,500 words, 1 table & fig.)

1907 **621 .131.2**
Railway Gazette, No. 8, February 22, p. 186.

National characteristics in locomotive building. (3,300 words.)

Railway Magazine. (London.

1907 **621 .33 & 625 .4**
Railway Magazine, No. 116, February, p. 89.

SEKON (G. A.). — The Great Northern, Piccadilly and Brompton Railway. (2,800 words & fig.)

1907 **621 .132.1 (.42) & 656 .222.1 (.42)**
Railway Magazine, No. 116, February, p. 99.

ROUS-MARTEN (C.). — British locomotive practice and performance. (4,200 words & fig.)

1907 624 .8

Railway Magazine, No. 116, February, p. 121.

JONES (C. H.). — Swing and other opening bridges. (4,000 words & fig.)

Railway Master Mechanic. (Chicago.)

1906 621 .134.4

Railway Master Mechanic, December, p. 478.

Some interesting types in development of four-cylinder compound locomotives. (2,200 words, 1 table & fig.)

1906 725 .33

Railway Master Mechanic, December, p. 491.

Round House with crane service—Denver & Rio Grande R. R. (800 words & fig.)

Railway Times. (London.)

1907 625 .246

Railway Times, No. 7, February 16, p. 177.

High capacity steel wagons for the Buenos Ayres and Pacific Railway. (500 words & fig.)

1907 621 .33

Railway Times, No. 8, February 23, p. 209.

The London and North Western electric railway. (2,200 words & fig.)

South African Railway Magazine. (Johannesburg.)

1907 625 .254

South African Railway Magazine, No. 6, February, p. 317.

SAMPSON (D. W.). — The automatic vacuum brake. (3,000 words & fig.)

Street Railway Journal. (New York.)

1907 621 .33

Street Railway Journal, No. 5, February 2, p. 191.

STILLWELL (L. B.) & ST. CLAIR PUTNAM (H.). — On the substitution of the electric motor for the steam locomotive. (13,000 words, 3 tables & fig.)

1907 621 .33 & 625 .4

Street Railway Journal, No. 7, February 16, p. 276.

Recent progress in heavy electric railway work at Philadelphia. (3,500 words & fig.)

Tramway & Railway World. (London.)

1907 621 .33 (09.1 (.45)

Tramway & Railway World, February, p. 97.

Milan-Galarate electric railway. (1,000 words & fig.)

In Italian.

Giornale del genio civile. (Roma.)

1907 62. (01 & 691

Giornale del genio civile, gennaio, p. 3.

Norme e condizioni per i materiali agglomeranti idraulici e per le opere in cemento armato. (12,000 parole, 2 tavole & fig.)

1907 621 .33

Giornale del genio civile, gennaio, p. 31.

La trazione elettrica sulle strade ferrate secondarie. (3,000 parole & 1 tavole.)

Ingegneria ferroviaria. (Roma.)

1907 621 .132.8

Ingegneria ferroviaria, nº 3, 1º febbraio, p. 34.

Automotrici ferroviarie. (800 parole & fig.)

1907 625 .231

Ingegneria ferroviaria, nº 3, 1º febbraio, p. 37.

CERRETI (U.). — Vetture e bagagliai. (1,200 parole & fig.)

1907 625 .143.5

Ingegneria ferroviaria, nº 3, 1º febbraio, p. 40.

JONGHI-LAVARINI (C.). — Sulla convenienza di generalizzare l'uso delle caviglie a vite mordente per fissare le rotaie alle traversine sulle linee ferroviarie a treni veloci e pesanti. (2,800 parole & fig.)

1907 621 .95

Ingegneria ferroviaria, nº 4, 16 febbraio, p. 50.

Perforatrici elettriche. (1,500 parole, 1 tavole & fig.)

1907 621 .131.2

Ingegneria ferroviaria, nº 4, 16 febbraio, p. 53.

FAVRE (E.). — Le particolarita' delle locomotive americane acquistate dalle ferrovie dello Stato nel 1906. (2,500 parole & fig.)

1907 **621**.132.3
Ingegneria ferroviaria, nº 4, 16 febbraio, p. 59.

Locomotiva compound a 4 cilindri gruppo 6-4-0 delle ferrovie dello Stato. (250 parole & fig.)

Rivista generale delle ferrovie e dei lavori pubblici. (Firenze.)

1907 **625**.144.1
Rivista generale delle ferrovie, nº 6, 10 febbraio, p. 83.

Lunghezza delle rotaie dei binari di corsa sulle grandi ferrovie francesi. (500 parole.) (V. *Bulletin du Congrès des chemins de fer*, nº 12, décembre 1906.)

In Spanish.

Gaceta de los caminos de hierro. (Madrid.)

1907 **385**.(03 & **62**.(03
Gaceta de los caminos de hierro, nº 2630, 16 de febrero, p. 74.

Diccionario técnico internacional de ferrocarriles. (1,600 palabras.)

Revista de obras públicas. (Madrid.)

1907 **621**.33
Revista de obras públicas, nº 1637, 7 de febrero, p. 69.

JENKIN (C. F.). — El pórvenir de la traccion electrica monofasica. (4,000 palabras.)

1907 **656**.212
Revista de obras publicas, nº 1638, 14 de febrero, p. 78.

CODERCH (D. R.). — Estación de Pueblo Nuevo. (7,000 palabras & fig.)

1907 **621**.134.3
Revista de obras públicas, nº 1638, 14 de febrero, p. 96.

Empleo del vapor recalentado en las locomotoras. (5,500 palabras, 2 cuadros & fig.)

1907 **625**.143.1
Revista de obras públicas, nº 1638, 14 de febrero, p. 101.

BARÓN (D. F.). — Sistema de via con carriles de acero de 40 kilogramos por metro lineal approbado por la Compañia de M. Z. A. (2,000 palabras & fig.)

1907 **621**.33
Revista de obras públicas, nº 1638, 14 de febrero, p. 104.

Energia necesaria para la explotacion eléctrica de los ferrocarriles suizos. (4,200 palabras & cuadros.)

1907 **656**.211.4
Revista de obras públicas, nº 1638, 14 de febrero, p. 112.

BALLESTEROS (D. M.). — Nueva estacion del ferrocarril del Norte en Valencia. (3,400 palabras, 1 cuadro & fig.)

1907 **385**.57
Revista de obras públicas, nº 1638, 14 de febrero, p. 117.

Instrucción profesional del personal de los caminos de hierro : la « Lecture and Debating Society » del « Great Western Railway ». (3,000 palabras.) (V. *Bulletin du Congrès des chemins de fer*, nº 11, novembre 1906.)

1907 **656**.211.4
Revista de obras públicas, nº 1639, 21 de febrero, p. 121.

PEIRONCELY (R.). — Estación definitiva de Cartagena. (1,600 palabras & fig.)

1907 **625**.172
Revista de obras públicas, nº 1639, 21 de febrero, p. 123.

OLANDA (L.). — La mano de obra en la conservación de una via ferrea. (16,000 palabras, 1 cuadro & fig.)

1907 **625**.13
Revista de obras públicas, nº 1639, 21 de febrero, p. 125.

GRASSET (E.). — Sustitución de puentes metálicos sin interrupción en el servicio. (4,400 palabras, 1 cuadro & fig.)

1907 **621**.131
Revista de obras públicas, nº 1639, 21 de febrero, p. 133.

CASTRO (E. de). — Locomotoras. (3,600 palabras & fig.)

1907 **625**.3 (.494)
Revista de obras públicas, nº 1639, 21 de febrero, p. 138.

LASSALA (J. J.). — Ferrocaril y túnel de la Albula (Thusis-Saint-Moritz). (6,000 palabras, 3 cuadros & fig.) (V. *Bulletin du Congrès des chemins de fer*, nº 7, juillet 1903.)

1907 **624**.(01
Revista de obras públicas, nº 1639, 21 de febrero, p. 152.

MENDIZÁBAL (D.). — Puente metálico sobre el Rio Manzanares en el km. 6,076 de la linea de Madrid á Alicante. (3,500 palabras, 2 cuadros & fig.)

In Dutch.

Ingenieur. ('s Gravenhage.)

1907 **656** .259
Ingenieur, nr 5, 2 Februari, p. 89.

MAAS-GEESTERANUS (H. P.). — Een nieuw toestel voor de contrôle van de snelheid van treinen. (3,600 woorden & fig.)

1907 **624** .8
Ingenieur, nr 8, 23 Februari, p. 145.

KERSEMAEKERS (J. M. H. R.). — Draaibruggen met één doorvaartopening. (1,000 woorden & fig.)

Vol. XXI. — No. 5. May, 1907. 12th Year of the English Edition.

BULLETIN
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INTERNATIONAL RAILWAY CONGRESS
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(ENGLISH EDITION)

[621 .132.1 (.42)]

BRITISH LOCOMOTIVES IN 1906.

DESIGNS AND WORK,

By Charles ROUS-MARTEN.

Figs. 1 to 4, pp. 483 to 486.

For the eleventh year in succession it is my duty to review the main features of British locomotive practice and performance in the year just ended. In accordance with my usual custom, for considerations of space, I confine my observations to the fifteen leading railways of Great Britain.

I. — Designs.

Taking the year as a whole, its chief feature appears to me to have been the steady convergence of a tendency toward uniformity of system. This may at first sight seem a strange contradiction of known facts, when the continued multiplication of different classes is considered. But more careful study will, I think, show that my view is a just one. For the multiplication has been rather that of *classes* than of types. It is true that two new types of express engines appeared during the year 1906, also two of goods engines and one of the tank class. But as a rule the year's novelties have been little more than class variants of types already existing, while the steadily rapid withdrawal from service of older types and classes has tended *pro tanto* to reduce the number of different locomotive-species, and so by the exhaustive process to approach uniformity more closely. This has perhaps been more extensively the case on the London & North Western than on any other line. Many of the old engines built by Mr. Ramsbottom before 1870 are now going to the scrap heap, including more than forty of the once-famous *Problems* with 7 ft. 6 in.

single driving-wheels, a few of his equally-famous 6 ft. 6 in. coupled (or *Newton*) type and a number of his goods engines known as the *DX* class. These engines were unsurpassedly excellent for their period and power, but they have lived their lives and done their work. It may well be doubted whether it were worth while to keep them up until they had attained an age of 40 to 48 years, and to " rebuild " them over and over again until little more than the name and number-plates were left of he original machines. This was notoriously the case as regarded the *Samson* class of 6 feet coupled which were ostensibly rebuilt in the nineties, the real fact being that entirely new engines having the small dimensions of the years 1860-1870 were built to fit the name-plates and number-plates of the small old machines. It is quite true that those new-old engines were most admirable so far as they went, but naturally they were outclassed by modern loads and could not be practically appraised as representing each the standard value of a modern locomotive for haulage purposes. A suspicion seems to have arisen, and to be likely to take root as a definite idea, that it is mistaken economy to persist year after year in rebuilding and patching up old locomotives which cannot even then do their due share of the work now required per engine. More than one of the leading British railways has something like 30 per cent of locomotives over 25 years old. These cannot practically be reckoned as more than two-thirds of an engine apiece in point of haulage value. The results of this practice are heavier aggregates of cost of labour and repairs without any real compensating benefit.

Nearly all of Mr. Webb's three-cylinder compound express-engines have been scrapped, and any that may still remain at the time I write, will go to the scrap-heap directly they next need heavy repairs. Among the number is the engine *Queen Empress* which was so extensively boomed at the Chicago Exhibition of 1893, but which proved unable to " live up to " her paper character.

There has been some rebuilding in the direction of converting an earlier class into a later and improved one. A notable instance is the Great Western conversion of the *Badminton* into the *City* class. The former were the pioneers of Mr. Churchward's latest type of inside-cylinder express engines. They had 18-inch cylinders, 26 inch piston stroke, and 6 ft. 8 in. wheels four-coupled, with leading bogies. They also had boilers of moderate size with steam-domes. The *Atbara* class which followed, were given larger boilers without domes. The *City* class which next came in, had domeless boilers coned outwardly at the fire-box end. Sixteen of the *Badmintons* and one *Atbara* have now been converted into the *City* class by the substitution of the large coned boiler, and all the others of those two classes are to follow suit. It may be remembered that engines of the *City* and *Atbara* classes enjoy the distinction of having attained the highest speeds ever authentically recorded, as noted in my previous articles.

Coming now to the absolute novelties of the year, I may say at once that these are Mr. Churchward's four-cylinder non-compound *Atlantic* on the Great Western, Mr. Worsdell's four-cylinder Smith-compound *Atlantics* on the North Eastern, Mr. McIntosh's 4-6-0 mixed traffic type, 908 class, and his 4-6-0 express goods engines 918 class, and Mr. Whale's ten-wheeled passenger tank-engines, No. 97 class and his 4-6-0 goods class. I do not include among the absolute novelties the very handsome and impressive *Atlantic* designed by Mr. Reid for the North British Railway, because it is practically only a variant of the gigantic type already in use on the North Eastern Railway, as is the London Brighton & South Coast *Atlantic* — illustrated last year (¹) — of the Great Northern *Atlantics*. But the other engines mentioned above all are exponents of virtually new principles, or at any rate each embodies at least one novel method in British locomotive engineering.

Thus the Great Western No. 40 recently designed and built by Mr. Churchward (fig. 1), to which he has given the historic name *North Star*, formerly borne by the original *No. 1* engine of the Great Western line — a 7 feet single-wheeler built in 1837 and only broken up last year, though long since withdrawn from service — is an *Atlantic* of the Great Western standard order, save for the two important particulars that it has four high-pressure cylinders each 14 ¹/₄-inches in diameter, two inside the frames and two outside, and that it has a 26 inches piston-stroke instead of the 30 inches stroke now given to all Great Western engines of the ordinary type. It will be obvious that with four 14 ¹/₄ inch cylinders, 6 ft. 8 in. coupled wheels, and 225 lb. steam pressure per square inch, this is nominally an engine of exceptional power, so far as the theoretic tractive force is concerned, but as its efficiency is necessarily limited by its available adhesion-weight, no demonstration is needed that much of its nominal power is wasted through the inadequacy of the adhesion obtained by four-coupled wheels. Consequently, Mr. Churchward has not only decided to build no more locomotives of this type with only four-coupled wheels, but has also discontinued building any ten-wheeled engines having only four-coupled wheels. This of course implies the abandonment of the *Atlantic* or 4-4-2 design on the Great Western. On the other hand, no fewer than thirty of the six-coupled 4-6-0 type are now in hand, of which ten, Nos. 4001-4010, have four cylinders all 14 ¹/₄ × 26 inches, two inside and two outside, but not compounded, while the other twenty, Nos. 2911-2930, have two cylinders 18 × 30 inches placed outside the frames.

Thus the four-cylinder non-compound design will have a drastic trial in this country, seeing that in addition to the eleven Great Western engines of this order which will be at work in the coming summer, there are ten already in use on the London & South Western, designed by Mr. D. Drummond. Of these, five have four-coupled wheels like No. 720, the pioneer of the order — which in her original shape I described and illustrated in my annual article on the British locomotives of 1897 (²); to the other five, Nos. 330-334, I referred last year. Both classes are reported as doing good work, but so far I have not observed any results better than

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(¹) Vide *Bulletin of the Railway Congress*, No. 4, April, 1906, p. 559.

(²) — — — — — No. 2, February, 1898, pp. 132 and 148.

those given by engines of much less weight and costliness. While the advantages of four cylinders are obvious, notably the superior balancing of the moving parts, these are purchased at a necessarily heavy increase in expense of construction and maintenance, while the benefits which would accrue from compounding are not obtained from the costly four-cylindered engine when of the single-expansion type.

But the attitude of British engineers toward locomotive compounding is, to say the least, a strange one. Because two systems of compounding — the Webb three-cylinder plan and the Worsdell-von Borries two-cylinder method, the *only* systems which have yet had a thorough and prolonged trial in Britain — have been condemned and abandoned, it is therefore most illogically asserted that " compounding " has been tried in this country and has failed. Such is not the case. Two *systems* of compounding — each of which had inherent and manifest defects — have been tried and condemned, but there has been no failure of compounding *per se*. On the contrary, there seems every reason to believe that the Smith three-cylinder system — the death of whose inventor I have the regret to record — is doing excellent service on the Midland and Great Central Railways. On the former line, the first batch of five Smith compounds — Nos. 2631-2635 — stands credited with the finest locomotive work without any exception ever performed on that railway, and now thirty or forty more of the same design, have been built or ordered by Mr. Deeley. The Great Central Smith-compounds built by Mr. Robinson are still in their trial stage, but there is no valid reason why they should not do as well as the Midland compounds. Shortly before his lamented death, Mr. Smith brought out a new compound design having four cylinders, and Mr. Worsdell built for the North Eastern Railway two very fine express engines of the 4-4-2 type on this principle. These also are stated to be doing satisfactorily, but I have not yet had the opportunity of making a personal test.

As regards the competitive trials on the Great Western of the three French four-cylinder compounds on the du Bousquet-de Glehn principle, specially built for that line, with engines of the two-cylinder non-compound British build, it is not easy to report definitely. Mr. Churchward himself, speaking at the Institute of Mechanical Engineers declared emphatically that the first of the French engines had done better work than any British four-coupled engine on the Great Western, and from Inspector Smith in the course of conversation, I gathered substantially the same thing. Yet now I find the latter gentleman saying in the course of a lecture, that the Great Western French compounds could not pull within 50 tons of the load hauled by the British-built four-coupled and six-coupled engines of that company. I am unable to " put this and that together, " especially in view of my own experience. I have never had the chance of comparing the work of the two classes of engines with really heavy loads, but I *have* had an opportunity of comparing their respective performances upon some of the severe Great Western gradients, with results which I shall set forth when I come to deal with the locomotive work of the year, simply

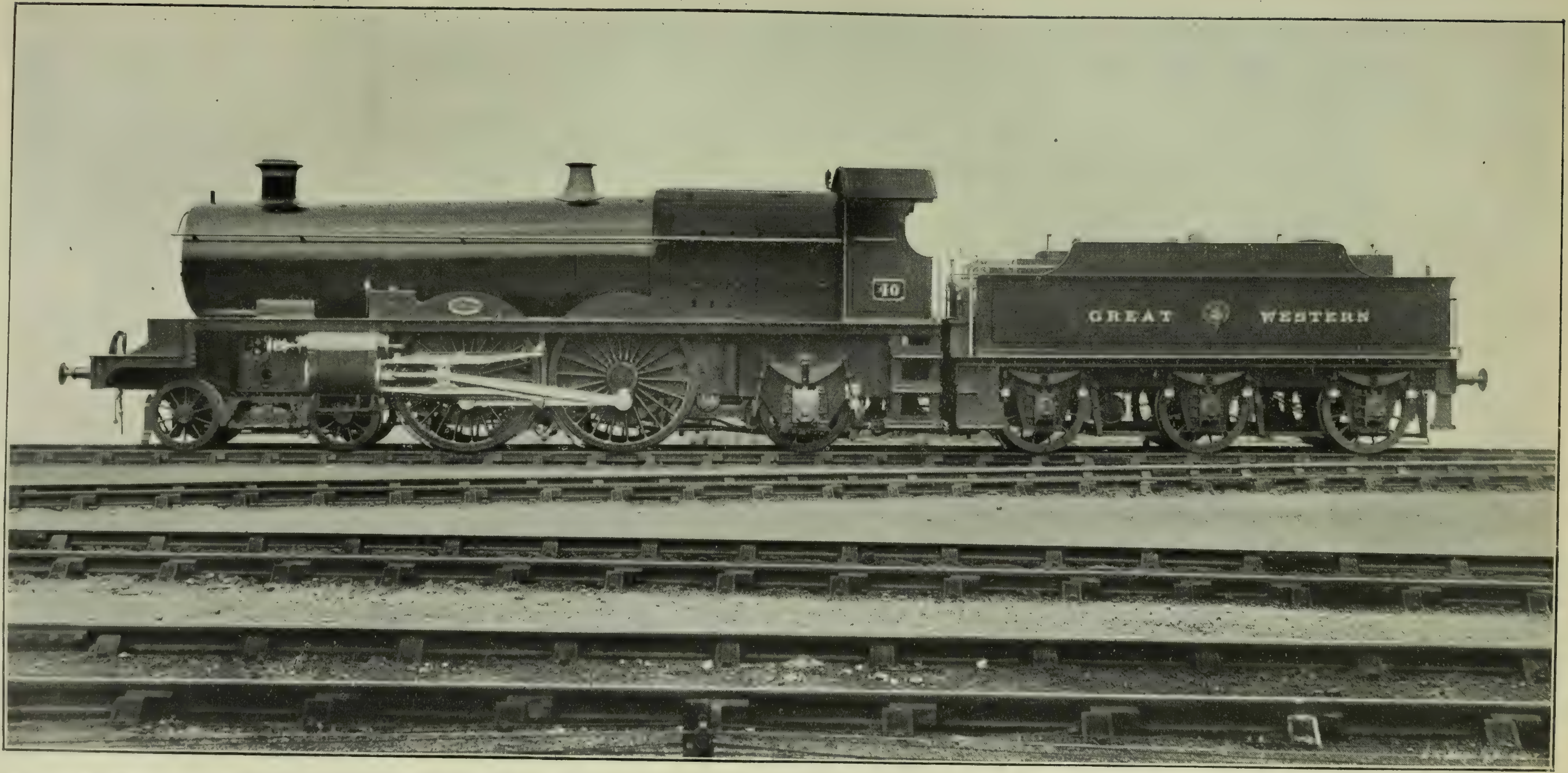
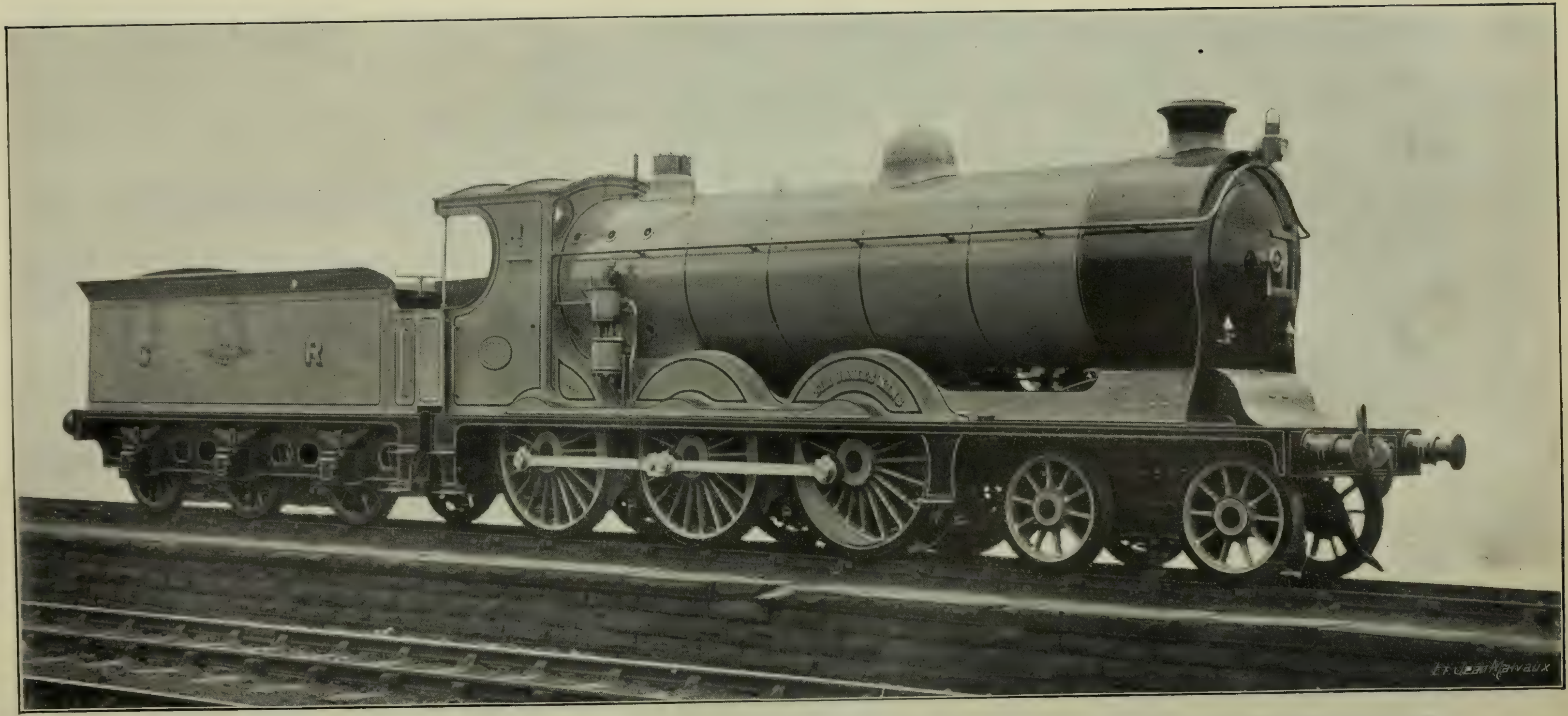


Fig. 1. — Latest type of express engine, Great Western Railway, No. 40, 4-4-2 or *Atlantic* class; Mr. G. J. Churchward. Cylinders (4), 14 1/4 × 26 inches; diameter of coupled wheels, 6 ft. 8 in.; total heating surface, 2,143 square feet; steam pressure, 225 lb.; total weight, engine alone, in working order, 74 1/2 tons; adhesion weight, 39 tons 12 cwt.; extended smoke-box; coned Boiler; Belpaire fire-box.



Ph. Jean Malvaux

Fig. 2. — New mixed-traffic type of locomotive, Caledonian Railway, No. 909, Mr J. F. McIntosh; cylinders, 19 × 26 inches; six-coupled wheels, 5 ft. 9 in.; heating surface, 2,178 square feet; steam pressure, 180 lb. Weight of engine in working-order, excluding tender, 64 tons.

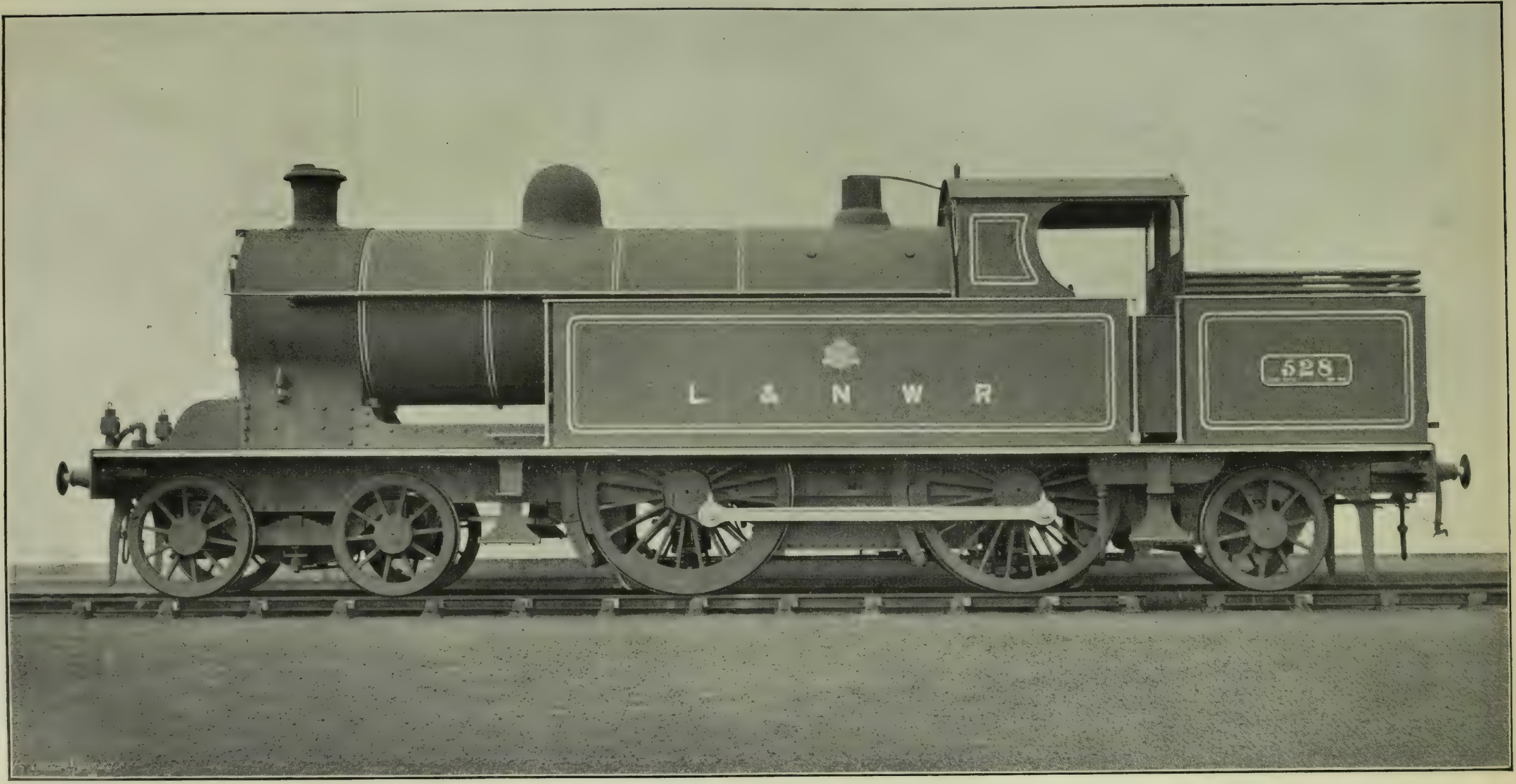


Fig. 3. — Latest type of tank engine, London & North Western Railway, Mr. G. Whale; cylinders, 19 × 26 inches; diameter of coupled wheels, 6 ft. 3 in.; total heating surface, 1,939 square feet; steam pressure, 175 lb.; total weight in working order, 75 $^3/_4$ tons; adhesion weight, 39 $^1/_2$ tons; height of boiler axis above rail, 8 ft. 7 in.; balanced valves worked by Joy's motion. The leading end of the engine is carried on a radial truck, which in addition to the turning motion of the ordinary truck, has a side play of 1 inch, this combined movement allowing greater freedom when going round curves. The trailing end is carried on a radial truck which has a side play of 1 $^1/_8$ inch. Designed for fast and heavy suburban traffic.

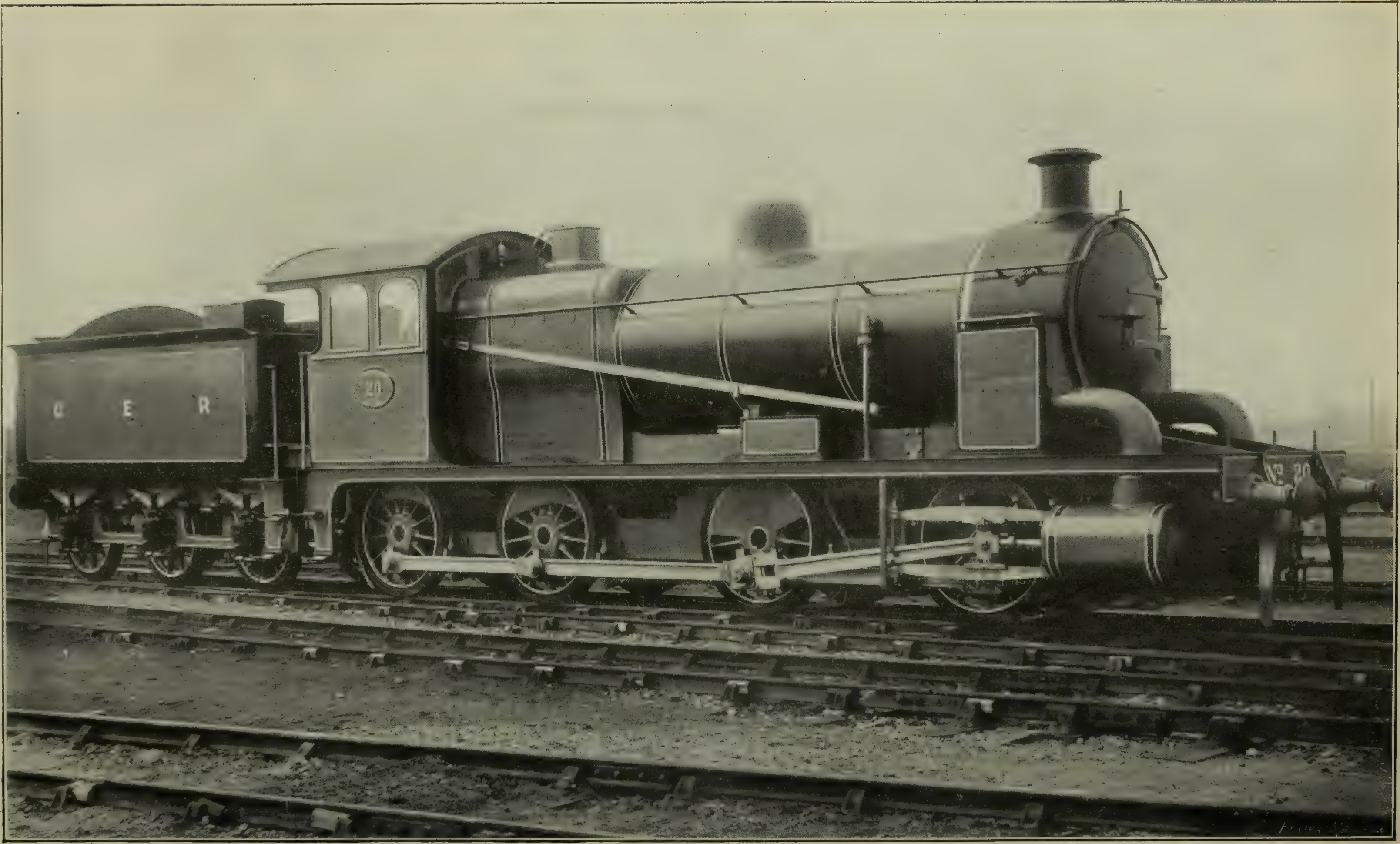


Fig. 4. — Latest type of goods engine, Great Eastern Railway, No. 20, Mr. J. Holden. Built for mineral traffic. Cylinders, 18 × 24 inches; eight-coupled wheels, 4 ft. 6 in.; heating surface, 1,869 square feet; steam pressure, 180 lb.

recording the facts *as* facts without being influenced by any personal bias as to the merits and demerits of locomotive compounding.

I have already mentioned in passing the new experiment in compounding which Mr. Worsdell is trying on the North Eastern Railway. He has built two express engines, Nos. 730 and 731, which are of the *Atlantic* type, compounded on the Smith system, but with four cylinders instead of three as in the case of the first Smith compound, No. 1619. The two high-pressure cylinders are 14 $^1/_4$ inches in diameter; they are placed outside the frames; the two low-pressure cylinders, placed inside, have a bore of 22 inches. All the cylinders have 26-inch piston-stroke, and all drive on one axle, the leading coupled one. The boiler is large, with 2,096 square feet of heating surface and a steam pressure of 200 lb. is carried; a modified form of Walschaert-gear is used. The total weight of the engine alone is 73 tons in working order.

A new *Atlantic* type of great size has been brought out by Mr. W. P. Reid on the North British Railway. It is of the two-cylinder simple-expansion order and has outside cylinders 20 × 28, like those of the North Eastern *Atlantics*. The boiler is of immense size with 2,256 square feet of heating surface, the steam pressure is 200 lb., the four-coupled wheels are 6 ft. 9 in. in diameter, and the total weight in working order is 74 tons 8 cwt. The diameter and elevation of the boiler are so large that hardly any room is left for the chimney, which rises only about a foot above the smoke-box casing, and is invisible to anyone standing on the road a short distance in front of the engine.

On the Caledonian line, Mr. McIntosh has built five more of his gigantic and very successful 4-6-0 class of express engines. They are virtually identical with Nos. 49 and 50 whose fine work I described in my article of four years ago (¹), differing only in minor dimensional details. But Mr. McIntosh has also introduced an entirely new class, practically of the mixed-traffic order, but of very large size. They may be described as intermediate between the *Oban* or *55* class — which have 5 feet coupled wheels — and the *49* class which have 6 ft. 6 in. wheels. The engines of the new, or *908* set (fig. 2), have 5 ft. 9 in. wheels six-coupled — the front coupled pair being the drivers — and leading four-wheel bogie. The cylinders, placed inside, are 19 × 26, and the boiler yields 2,178 square feet of heating surface. The steam pressure is 180 lb. All of these *Caledonian* 4-6-0 classes are doing excellent work, and the type is likely to prevail henceforward on account of the valuable increment of adhesion weight which it possesses. It might with advantage be adopted on other British lines.

Among the tank engines of 1906, the most striking are the ten-wheeled 4-4-2 classes brought out respectively by Mr. Churchward on the Great Western and by Mr. Whale on the London & North Western (fig. 3). They are very similar in point of power. The Great Western tanks have 6 ft. 8 in. coupled wheels and

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(¹) Vide *Bulletin of the Railway Congress,* No. 4, April, 1904, pp. 292 and 296.

outside cylinders 18 × 30. The London & North Western engines have 6 ft. 3 in. coupled wheels and inside cylinders 19 × 26. The latter have large boilers of the *Precursor* order and weigh 74 $^3/_4$ tons in working order. The Great Western tanks are virtually tenderless *County* class engines. Both classes are doing well, and those of the London & North Western are already thirty in number. They are superseding the previous standard tanks of 2-4-2 class with 5 ft. 6 in. wheels.

Of the year's new goods-engines the most noteworthy have been two, *viz.* 1) the eight-coupled Great Eastern, No. 20 (fig. 4), into which Mr. Holden has converted his famous experimental *Decapod* whose genesis and fate I related in my articles of 1902 and 1906 (1). The new No. 20 has a boiler 13 feet long and 4 ft. 9 in. in diameter, with 1,869 square feet of heating surface and 180 lb. steam pressure. The two cylinders are outside and are 18 $^1/_2$ × 24. The eight coupled wheels are 4 ft. 6 in. in diameter, and the total weight of the engine is 54 tons 6 cwt. The fire-box is of the Belpaire type. 2) The other is Mr. McIntosh's bogie goods engine No. 918 on the Caledonian, which is of the 4-6-0 class and is in fact an *Oban* with enlarged boiler having 2,018 square feet of heating surface. This is a very powerful and useful engine particularly suited to the sharp curves that abound on the Caledonian Railway.

Glancing over the year's practice, apart from novelties, I may note that on the Great Western, Mr. Churchward is multiplying his *County* class for service on those parts of the Great Western system for which the heavy ten-wheeled locomotives are unsuitable. Mr. Whale, on the London & North Western, has multiplied both his *Precursor* and *Experiment* types and is bringing out a new 4-6-0 goods class. On the Midland, Mr. Deeley has increased the number of three-cylinder Smith compounds, *1000* class, and has given larger boilers to many engines, both passenger and goods, of his predecessor's build. Mr. Worsdell has built for the North Eastern more of his 4-6-0 *2001* class, but uses them for mixed traffic rather than for express duty. For the Great Central, Mr. Robinson has turned out more of his fine 4-4-2 — both single-expansion and compound — and 4-6-0 types, with good results. No single wheelers were built or planned during 1906, and at present it seems unlikely that the type will be perpetuated.

II. — **Work**.

Coming now to the work actually performed during the past year under my own observation, it may I think be fairly classified as satisfactory rather than sensational or spectacular. A great deal of remarkably fine locomotive work was done, but no fresh " records " were set up either in speed or in load-hauling. Reviewing the respective performances in the order of precedence given by Bradshaw to the various railways, the Great Western comes first. This line has deservedly won high credit for the remarkable service of expresses which it established or improved during the summer, and created a precedent by maintaining during the winter. The opening of the new direct line from London to Devonshire and Cornwall which shortened the distance between the Metropolis and every place from Taunton onward amounts to an absolute revolution in the particulars and character of the work prescribed for Great Western engines. Starting from London the westward-bound trains, on reaching Reading, 36 miles from the start, turn off to the left, leaving the old mainline which is not rejoined until a point 127 miles farther on is reached, a distance of just 20 miles being thus saved. The new route, much of which consists in a linking up of old reconstructed branches into one splendidly built main line, although generally free from severe gradients, has one fairly steep " pinch " near Witham.

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(1) Vide *Bulletin of the Railway Congress*, No. 4, April, 1903, p. 285, and No. 4, April, 1906, p. 556.

But the drop of nearly 2 miles at 1 in 100 near Wootton Bassett and 2 $^1/_2$ miles at 1 in 100 and 1 in 120 through the Box tunnel, both on the down journey, and also the slow to 15 miles an hour through the curved Bath station and to 10 miles an hour round the very sharply-curved deviation line by which the Bristol station is avoided, both are escaped. Thus the new route opens up a fresh scope for locomotive performance, of which full advantage will doubtless be taken in due course. At present the process of consolidation is hardly complete. Nevertheless, non-stopping expresses are now booked from Paddington to Exeter, 173 $^3/_4$ miles, in the even 3 hours each way, a saving of 25 minutes. Three trains are thus booked, an average speed of 57·9 miles an hour being involved. The important stations of Bath and Bristol with their numerous connections are of necessity ignored by the new route, but both are provided with excellent services; Bristol in particular has no fewer than four trains which cover the distance of 118 $^1/_2$ miles between that point and London in the even 2 hours, thus averaging 59·2 miles an hour. It is necessary to make quite clear the vast alteration which has taken place, in order that the performances of the past year and those of future dates may be accurately appraised as to value, in comparison with those which I have recorded in previous years. On the present occasion, it will suffice if I give my experience of a journey each way over the new route. On the down journey, the engine was No. 2902, of the same class as Nos. 100 and 177 whose performances I mentioned in each of the last two years, that is to say the class was 4-6-0, six-coupled wheels each 6 ft. 8 in. in diameter, cylinders placed outside the frames, 18 × 30 inches. The load was a moderate one, approximately 200 tons behind the tender; the weather was wet with a strong wind. I may remark that at no point during the journey was any attempt made to attain exceptional speed; the results were obtained by uniform excellence of work. Thus Reading, 36 miles, was passed dead slow in 33 minutes 58 seconds from the start, and a distance of exactly 125 $^1/_2$ miles was covered in the first two hours from London, although there had been several serious slowings over the new formation. Thenceforward, the running was done under very easy steam in order to avoid a too early arrival. Nevertheless, Exeter was reached, after a signal slack outside, in

2 hours 57 minutes 12 seconds from London. I may note incidentally that a minimum rate of 45 miles an hour was sustained up the Wellington bank of 1 in 80 and 1 in 81. In the opposite direction, No. 104, one of the two larger French compounds, hauling approximately 150 tons behind the tender, gave me a striking performance up the formidable Hemerdon bank, a rise of 2 1/4 miles continuously at the rate of 1 in 42. Up this extremely severe grade, a minimum of exactly 30 miles an hour was persistently maintained to the summit. This is even a finer performance than that mentioned in my article of 1905 (1) when, in the Record Run of the Great Western Ocean Mail Special, No. 3440, *City of Truro*, hauling a similar load, sustained a minimum of 28 miles an hour up the same bank, touching the summit in 4 minutes 23 seconds from Plympton, a distance of 3 miles 20 chains. No. 104, however, accomplished that same distance in 17 seconds less time, *i. e.* in 4 minutes 6 seconds. Another interesting comparison may be made between the same two engines up the later and less severe ascent from Exeter to Whiteball Summit, a distance of just 20 miles, which No. 3440 climbed in 19 minutes 29 seconds and No. 104 in 19 minutes 23 seconds, the latter being the quicker by 6 seconds. In these cases, therefore the compound had clearly the better of it uphill. I may observe in passing, that I have timed each of the three French compounds on the Great Western down falling gradients, at 90 miles an hour, which agrees within a small fraction of the maximum I obtained when testing engines of the same class on French railways.

Next in order comes the London & South Western, on which my principal experience was with the best express from London to Exeter and back. This distance of 171 1/2 miles is divided into two sections, London-Salisbury 83 1/2 miles, Salisbury-Exeter 88 miles, each of which is worked by a different class of engine, differing from one another, however, only in the size of the coupled wheels which are 6 ft. 7 in. in diameter in the case of those used between London and Salisbury, where the gradients are generally easy, and 6 ft. 1 in. in diameter between Salisbury and Exeter where the grades are exceptionally severe and prolonged. For the down journey from London to Salisbury the time allowance was 92 minutes; for the up, 91 minutes, averaging respectively 54·5 and 55·1 miles an hour from start to stop. On the down journey, the engine was No. 415, having four 6 ft. 7 in. coupled wheels and inside cylinders 19 × 26 inches; the load was 180 tons behind the tender. The run was made at a uniform moderate speed; a permanent-way slack near Andover Junction caused a slight loss of time which was not made up, but the net time was that booked. On the up journey a sister engine, No. 416, took the train which weighed slightly over 200 tons behind the tender. On this occasion also, the booked time was slightly exceeded, but two slacks for signals and one for relaying had caused a loss of 6 1/2 minutes, consequently the net time was 84 3/4 minutes for the 83 1/2 miles, showing a gain of 6 1/4 minutes. On the second and more steeply-graded stage, the engine each way was No. 399, which differs from No. 415 merely in having driving wheels 6 inches smaller; the loads each way were the same as between London and Salisbury. Notwithstanding a bad slack for relaying near Whimple, the down journey from Salisbury to Exeter was performed in 96 minutes 57 seconds or 63 seconds less than schedule. The minimum uphill speeds were 36 miles an hour up 1 in 80, 31 miles an hour up 1 in 70 — both distinctly creditable; a downhill maximum of 88·2 miles an hour was attained. On the up journey with the heavier load, a stop was made at Sidmouth, from which point to Salisbury, a distance of 76 miles, we ran in 84 $^1/_2$ minutes. Once more the lowest speed up the long banks at 1 in 80 was 36 miles an hour. Downhill a slightly higher maximum was reached, exactly 90 miles an hour, the travelling being perfect in smoothness and steadiness.

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(1) Vide *Bulletin of the Railway Congress*, No. 8, October, 1905, p. 2120.

Upon the South Eastern & Chatham Railway my most interesting experiences were a journey from London to Dover and another back, with No. 504, one of the new express engines designed by Mr. H. S. Wainwright and built at his Ashford Works, differing from his standard 4-4-0 type in having 6 ft. 6 in. coupled wheels instead of 6 ft. 8 in., and a Belpaire fire-box instead of the ordinary pattern. The load, officially reckoned as " 20 coaches " weighed, roughly, 300 tons behind the tender. The time allowance is liberal, 100 minutes for the 74 miles from Herne Hill — where the City and West-End portions unite — to Dover, averaging 44·4 miles an hour, but the road in each direction abounds in steep gradients, *e. g.* 1 in 95 to 1 in 100, while the compulsory slowings round the sharp Rochester curve and through Dover town on to the Admiralty Pier constitute serious hindrances, especially to a 300-ton train. In spite of a relaying slack on the down journey, booked time was improved upon to the extent of nearly 2 minutes. The lowest speed up the 1 in 95 near Bickley was 33 miles an hour, and up the 1 in 100 grades, 36 miles an hour. Moderate rates were in every case maintained downhill. The time of the up journey, with the same load and locomotive differed from that of the down one, curiously enough, by only two seconds, a remarkable instance of uniform work. Up the 6 miles at 1 in 100 to Sole Street, starting dead slow from the Rochester curve, the speed as usual dropped temporarily to 27 miles an hour, but it had recovered to 30 before the top of the bank was reached. The maximum downhill speed was 72·6 miles an hour. Mr. Wainwright's engines do their work excellently and fulfil all the present requirements of the line.

Mr. Ivatt's fine *Atlantics* gave me several interesting experiences on the Great Northern Railway. My chief attention was naturally devoted to his own compound, No. 292, and to the other compound, No. 1300, built by the Vulcan Company virtually upon the de Glehn system, both of which I described last year (1). No. 292 hauling 300 tons behind the tender, in spite of three bad relaying slacks, ran from London to Peterborough, 76 miles 29 chains, in 81 $^1/_2$ minutes inclusive, or in 75 minutes net, passing Potter's Bar — 12 $^3/_4$ miles including 8 $^1/_4$ miles of

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(1) Vide *Bulletin of the Railway Congress,* No 4, April, 1906, p. 558.

1 in 200 up — in 19 minutes 2 seconds, at a minimum rate of 45 miles an hour. The second stage, Peterborough to Doncaster, 79 1/2 miles, occupied 85 minutes 49 seconds inclusive, 4 minutes being lost by signal and relaying slack. Ascending the long bank to Stoke tunnel, the minimum rate up the final 3 miles of 1 in 178 was 48·4 miles an hour, and up the 1 in 198 to Piper's Wood, 52·8 miles an hour. Another run among several with the same engine, was with the heavy up express from Leeds, due in London at 9·25 p. m. In this case, the load behind the tender was 330 tons. The first stage of 50 1/2 miles from Doncaster to Grantham, was marred at the end by three signal stops, but the distance of 48 1/2 miles from the start to the first signal stop was run in 54 minutes. The final stage of 105 1/2 miles from Grantham to London occupied 117 1/2 minutes, the lowest speed up the long ascent at 1 in 200 to Stevenage being 47 miles an hour. The five uphill miles — mostly at 1 in 200 — from Hatfield to Potter's Bar were covered in 5 minutes 3 seconds. Both journeys represent highly creditable work. With No. 1300 my experiences were unlucky owing to her tendency to " run hot ", but in one case with 300 tons behind her tender, she ascended the bank from London to Potter's Bar, 12 3/4 miles, in 18 minutes 43 seconds, the minimum rate being 47·8 miles an hour, while down the easy descent after Hitchin she did the 12 miles to a signal stop at Sandy in 9 minutes 39 seconds, so that her capacity for high speed is indisputable. By the large Atlantics of the single-expansion type, several good runs were made, particularly by No. 294 which differs from the rest of the *251* class in having 200 lb. steam pressure instead of 175 lb. Hauling 300 tons behind her tender, No. 294 climbed the bank to Potter's Bar in the quick time of 16 minutes 23 seconds, the sustained rate up 1 in 200 being 52·8 miles an hour. Notwithstanding three very bad permanent-way slows, the time from London to Peterborough was only 80 minutes 38 seconds; the net time was 74 minutes. The second stage, Peterborough-Doncaster occupied 83 minutes 3 seconds inclusive, or 81 minutes net, the minimum rates being 52 miles an hour up the 1 in 178 to Stoke, and 52·8 up the 1 in 200 to Askham and 1 in 198 to Pipers Wood. No. 278, of the same type, but with 175 lb. steam-pressure, took a Scotch express of 310 tons from London to Grantham in 114 1/4 minutes, passing Potter's Bar in 17 minutes 31 seconds, Peterborough in 78 minutes 51 seconds, with a bad slow near Tempsford. The uphill minima were 47·4 to Potter's Bar, and 49·5 to Stoke. It was curious that the speed had dropped to 45 miles an hour up the earlier and easier part of the Stoke bank, but up the final 3 miles at 1 in 178 it steadily increased to 49·5, and was still rising when the summit was reached.

On the London & North Western, I had a number of extremely good runs, almost exclusively with Mr. Whale's two standard types, the *Precursors* and the *Experiments* which I described and illustrated in my articles in 1905 and 1906 respectively (1). The work done was so consistently good that it is difficult to select specimen performances. One by the 5·55 p. m. express which is booked to reach Liverpool (Edgehill), 192 1/4 miles, in 3 hours 28 minutes from London, without intermediate stop, was particularly noteworthy for its smartness. Engine No. 837, *Friar*, hauling 270 tons behind its tender, accomplished this journey in 3 hours 23 minutes 13 seconds, passing Rugby, 82 1/2 miles, in 86 minutes 20 seconds; Stafford, 133 1/2 miles, in 2 hours 16 minutes 16 seconds; Crewe, 158 miles, in 2 hours 43 minutes 55 seconds. In the opposite direction No. 2017, *Tubal*, with practically the same load ran from Stafford to the entrance of Euston station in 128 minutes net, the net time from Liverpool being 3 hours 18 minutes. On the Scotch day express, No. 374, *Empress*, took 380 tons from London to Rugby in 91 minutes, and on the corresponding up-train, No. 723, *Coptic*, brought 400 tons from Crewe to Rugby, 75 1/2 miles, in 81 minutes 3 seconds, the lowest speed up the Madeley bank, 3 miles at 1 in 177, being exactly 40 miles an hour with that enormous load, and the time from passing Stafford to stopping at Rugby, 51 miles, being only 50 minutes 12 seconds. The succeeding run from Rugby to London was done in 84 minutes 35 seconds, Willesden (77 miles) being passed in 76 minutes 57 seconds, and the 15 miles ascent from Bletchley to Tring being accomplished in 15 minutes 57 seconds. Some of the runs made by the London-Birmingham expresses which are allowed only 2 hours each way for the journey of 113 miles, were extremely smart. In one case No. 60, *Dragon*, with 230 tons, performed the ascent of 31 3/4 miles from Euston to Tring in 32 minutes 24 seconds, the best in my experience, the minimum rate up the last 6 miles of 1 in 330 being 65·2 miles an hour which had increased to 67·5 before the summit was reached. Bletchley was passed in 45 minutes 4 seconds, and Roade (60 miles) in 57 minutes 14 seconds from Euston; the 80th mile-post in 77 minutes exactly; Rugby 79 minutes 54 seconds. Coventry was passed in 84 minutes 27 seconds from Willesden, 88 1/2 miles, and we stopped at the entrance of Birmingham station 112 minutes 24 seconds from London, after " easing down " all the way after Coventry as we were before time. One up journey when No. 311, *Emperor* was the engine also deserves mention, the 113 miles to London being performed in 108 minutes with a load of 140 tons. Coventry was passed in 17 minutes 39 seconds from Birmingham, and Rugby (30 1/2 miles) in 27 minutes 36 seconds. Good service was also done by the *Precursor* engines on the severe Lancaster-Carlisle section. No. 103 *Aurania* took 310 tons from Carlisle to Lancaster, 69 miles, in 80 minutes 59 seconds, maintaining 40 miles an hour up the banks at 1 in 125 and 1 in 132.

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(1) Vide *Bulletin of the Railway Congress*, No. 8, October, 1905, p. 2117, and No. 4, April, 1906, p. 558.

With the 4-6-0 or *Experiment* class, I had several interesting experiences. In one case No. 978, *City of London*, hauling the huge load of 409 tons behind her tender, ascended the bank to Tring in 42 minutes 14 seconds from Euston, the minimum rate up 1 in 330 being 50 miles an hour and the maximum down a like grade 75; sustained a minimum rate of 54·9 miles an hour up the 7-mile bank at 1 in 350 to Roade, and 56·5 miles an hour up the similar grade to the Kilsby tunnel, and stopped at Rugby, 82 1/2 miles, in 91 minutes 44 seconds from London, 80 minutes

39 seconds from passing Willesden (77 miles), certainly a very remarkable feat with so gigantic a load on by no means invariably easy grades. The same engine with 200 tons, did the 90 miles steeply graded run from Preston to Carlisle in 98 minutes net, easing down all the way after Shap Summit, maintaining minimum rates of 39 miles and 25 miles an hour respectively up the Grayrigg (1 in 100) and Shap (1 in 75) banks. No. 1074, *City of Dublin*, took 320 tons from Euston to Crewe in 2 hours 55 minutes 33 seconds. No. 507, *Sarmatian*, with 280 tons, ran from Crewe to Willesden, 152 $^1/_2$ miles, in 2 hours 35 minutes 51 seconds inclusive or 2 hours 33 minutes net, the time from Rugby to Willesden (77 miles) being only 74 minutes 15 seconds and from Bletchley to Tring 15 minutes 50 seconds; the minimum rate up the 6 miles of 1 in 330 was 53 miles an hour.

On the North Eastern Railway, one of the large *Atlantics*, No. 1792, look a load of 300 tons from Newcastle to Berwick, 67 miles, in 69 minutes 3 seconds inclusive, sustaining a speed of 47·4 miles an hour up a long rise at 1 in 170. Also a remarkable performance was accomplished by No. 1522, one of the old single-wheelers with 7 ft. 7 in. drivers and inside cylinders 19 × 24 which, starting from Newcastle with a load of 280 tons, maintained a minimum rate of 40 miles an hour up the Plawsworth bank of 1 in 150, and reached Darlington, 36 $^1/_4$ miles, in 43 minutes 58 seconds, next running from Darlington to York (44 $^1/_4$ miles) with that load in 44 minutes 28 seconds from start to stop — very fine work for an engine of the class and power.

Upon the other British railways than those already noticed, I recorded no performances during the year better than those which I have described in previous years or calling for special mention. I may note as usual that all observations were made by myself personally, and all train-weights given are exclusive of engine and tender.

[621 .14]

THE PRESENT COST OF MOTOR BUS SERVICES,

By Mr. VELLGUTH,

GENERAL SECRETARY, BERLIN.

(From *Archiv für Eisenbahnwesen.*)

Soon after petrol-driven motor cars first appeared, it was easy, taking into consideration the advanced state of engineering knowledge, to foresee that the new vehicles would soon claim a place among public conveyances. This expectation has now been realized, and the motor bus has already been tried at many places; every day new undertakings of the kind are started and manufacturers are full up with orders for a year or more ahead.

The rashness with which speculators, whether on the large or on the small scale, undertake the risks inherent to such an enterprise, is however not peculiar to the case of motor buses, but is to be found in connection with all transport undertakings in the whole world; however, it only becomes strikingly apparent when, as in this case, new inventions or new developments are continually taking place. We may instance the initiative shown everywhere in Prussia when the « Kleinbahnen » law came into force (1).

Two factors which do not come into play in other cases help to attract capital, which is generally so cautious, to transport enterprises, without any definite proof that the undertaking will be remunerative. When the capital is found by public bodies, every new transport system may prove an advantage, even if the capital invested returns no interest. The resulting improvement in the economic conditions of the district concerned, may then compensate for the immediate loss incurred. In the case of a private company, however, in the absence of the latter condition, the object in view is the prospect of gain. It might therefore be thought that in such a case the probable return would be worked out with very great care. But this is by no means the case. Appearances dazzle the capitalist, particularly the small capitalist, to such an extent that he is satisfied with the roughest estimates and trusts the rest to luck. He sees that other undertakings easily make money, he sees the traffic which will give him his receipts, and confounds receipts with profits.

This is the sole explanation (2) of the foundation of many transport enterprises, road and rail, which after several years of existence either hardly earn enough to cover their working expenses proper, or else have ceased to exist.

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(1) The Prussian law of 28 July, 1892, defines *Kleinbahnen* (minor railways) as iron roads for conveying traffic inside one commune or between adjoining communes, such as the lines on which steam traction is not used. (*Note by the Editor.*)

(2) The magnitude of the boom now on in England is well shown by the following statements extracted from the *London Financial Times*. In England alone, the total issues for new works or com-

What is really lacking, is a knowledge of the expenses. On account of the great interest which the competition of motors has for tramways and light railways, the author has done his best, during the last two years, to collect information on this question of expenses. His first attempts were more or less without result. In spite of the considerable number of minor enterprises, it was not possible to obtain any useful information, and it is easy to understand why this should be so. Many of these small undertakings, after starting full of hope, have disappeared; they did not keep records of their mileage or of the details of their expenditure. Although such particulars have been recorded in some isolated cases, they are hardly of any use for our purpose, because information, indispensable to us, as to profile of the roads, their condition, and the system of maintenance adopted, is lacking. Other small undertakings, which continue to exist, have an interest in concealing their expenditure.

It is only during the last nine months that the author has obtained detailed and utilizable information as to the results obtained by several important German undertakings and English companies. Part of this information has been published in the reports of the German undertakings, but the rest, much the greater part, has been collected privately and during journeys, when investigations were made on the spot, particularly in England.

Utilizable information has been supplied by the following undertakings :

IN GERMANY :

Dettmannsdorf-Marlow, in Mecklenburg. Macadam road 6·1 kilometres (3·8 miles) long, well kept, nearly level, gradients varying between 1 in 32 and 1 in 18 on a length of 700 metres (765 yards) only; service worked by two Daimler motor buses (one as reserve) of 16/21 horse-power, 700 to 800 revolutions per minute, four speeds, from 4·9 to 18 kilometres (3 to 11·2 miles) per hour; speed actually attained, 21 kilometres (13 miles) per hour; tare 3·9 tons; two compartments, one for 5 second class and one for 8 third class passengers; two more seats, if wanted, next the driver; mean speed, 15 kilometres (9·3 miles) per hour (there are no stops); service started August 1, 1904; period covered by report, 1 year, till August 1, 1905; daily performance, 5 journeys; total mileage, 22,771 kilometres (14,149 miles). The service belongs to and is operated by the Mecklenburg Railway, Schwerin Directorate.

Partenkirchen-Mittenwald-Walchensee-Kochel. Total length, 52 kilometres (32·3 miles); good mountain road, 6 to 7 metres (19 ft. 8 in. to 23 feet) wide. Steepest gradients 50 to 55 per mil on a length of 4·5 kilometres (2·8 miles), 50 per mil on a length of 2·8 kilometres (1·7 miles); radii of sharpest curves, 25 to 30 metres (1 1/4 to 1 1/2 chain); service worked by three N. A. C. motor buses (one as reserve) of 20/24 horse-power,

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panies, during the first five months of 1906, amounted to £6,695,000. Of this amount, £1,946,000 were for works, £1,165,000 for country lines and £3,584,000 for new bus companies in London. This does not include the large sums expended by existing bus companies, formerly using animal traction only, on motor buses.

1,300 revolutions per minute; four speeds, from 5 to 35 kilometres (3 to 21·7 miles) per hour. Type, open car with fixed top for luggage. Maximum capacity, 14 passengers. Tare, 1·9 tons; speed, stops included, 15 kilometres (9·3 miles) per hour; service started June 1, 1905. Summer service only, from June to end of September; according to section and season, 2 to 8 journeys in each direction per day; period covered by report, June 1 to end of September 1905; total mileage 33,712 kilometres (20,948 miles). Operators : Munich Local Railway Company and the postmasters at Partenkirchen, Mittenwald and Walchensee.

Sonthofen-Hindelang. Total length, 7.6 kilometres (4·7 miles); Bavarian national road without sub-foundation, according to official report in proper condition; but according to recent personal communications, it must be considered a bad road for motor cars. Mountainous district, gradients up to 70 per mil. Two Daimler cars, tare 4·5 tons, 28 horse-power, four speeds from 4·9 to 21 kilometres (3 to 13 miles) per hour, 21 passengers; one motor van, tare 3.5 tons, 21 horse-power, maximum speed 18 kilometres (11·2 miles) per hour, floorspace, 4 by 2 metres (13 ft. 1 1/2 in. by 6 ft. 6 3/4 in.), to carry 3 tons, four speeds from 4·9 to 18 kilometres (3 to 11·2 miles) per hour. The cars and the van can take gradients of 120 per mil. The van also has rubber tires. Passenger service : 16 journeys per day in summer, 14 per day in the other seasons. Goods service : as required. Service started August 1, 1905; period covered by report, from August 1 to December 31, 1905. Total mileage in 184 days : passengers, 19,744 kilometres (12,269 miles); goods, 3,897 kilometres (2,422 miles). The service belongs to the Royal Ministry of Ways and Communications of Bavaria; executive manager, the local postmaster.

In England :

London : a number of different companies owning at present about 500 or 600 petrol motor buses; the first began running about twenty-one months ago. The paving is very good in London; much of it is wood. The roads are generally level.

There are other services at Hastings, Birmingham and Bath, with about 40 motor buses.

Thus there are already a considerable number of cars, working under very varying conditions. One would feel inclined to think that it would be easy for a tramway engineer to ascertain what the working expenses amount to. Such is the case with the German enterprises mentioned above; but as our list shows, it is especially in England that figures of importance are to be sought. Now there nearly all the motor buses are operated by large and even very large companies, and much speculation in the shares of these companies is taking place. The *Financial Times* remarks that it is quite as much a fashion to own a few such shares as to ride on horseback or to play tennis. In 1905, dividends of 10, 15 and 20 per cent were paid on such London shares. Any unfavourable information as to cost, if it leaked out, might result in a tremendous slump. The result of this state of affairs, is an abnormal discretion on the part of those in the know, who refuse to give any information except under quite exceptional conditions.

There was an occasion of the sort in the spring of this year. Mr. Manville, one of the most eminent consulting engineers of London, who had been accused of propaganda in favour of motor buses, he being consulting engineer of a number of tramways, felt called upon to defend his position, and read a paper before the Automobile Club of London, on the comparative cost of tramway and motor bus services; his conclusions were against the latter. This paper, the reputation of its author, and the place where the paper was read, namely the Automobile Club, induced the motor bus people, for the first time, to come out of their shell and during the discussion exchange views with the tramway people and others concerned in means of transport. The discussion extended over two evenings, and is a valuable mine of information on the working of motor buses in London; it has also had the result that more of the public were led to examine the question.

Let us in the first place consider the working expenses in detail. They may be classified under the followings heads :

1. *General management :* salaries of manager and indoor staff, rent and furniture of offices, stationery, law expenses.

This expenditure amounts to 4 pfennigs per kilometre (0·77*d.* per mile) on small tramways, from 2 to 3 pfennigs per kilometre (0·38*d.* to 0·58*d.* per mile) on those of medium importance and to about 1 to 2 pfennigs per kilometre (0·19*d.* to 0·38*d.* per mile) in the case of large undertakings. We may assume that these figures would also apply to motor bus services.

2. *Operating staff :* drivers and conductors.

On large undertakings, a driver receiving as pay 130 marks (£6.10*s.*) per month, costs, including insurance as by law established, leave, uniform, etc., about 150 marks (£7.10*s.*) per month; according to tramway figures he works 27 days, of 7 hours net running time each; the mean speed being 14 kilometres (8·7 miles) per hour, this gives a total mileage of 2,646 kilometres (1,644 miles) per month. The cost is therefore 5·7 pfennigs per kilometre (1·10*d.* per mile). On small undertakings, the pay is at least 110 marks (£5.10*s.*) per month; say 125 marks (£6.5*s.*) per month with all extras included. If we assume the mean speed to be 15 kilometres (9·3 miles) per hour, the cost will in this case be rather less, namely 4·4 pfennigs per kilometre (0·85*d.* per mile).

The cost of a conductor, including clothing and insurance as by law established, is 110 marks (£5.10*s.*) per month. In the case of very large undertakings, where a well-organized time table enables a conductor to work longer than a driver, his net time may be 8 hours per day, which with 27 days per month and a speed of 14 kilometres (8·7 miles) per hour gives a total mileage of 3,024 kilometres (1,879 miles); the cost is therefore 3·64 pfennigs per kilometre (0·70*d.* per mile). It is however probable that this will rarely be the case. Generally the working hours will be the same as those of the driver, and the cost then becomes 4·2 pfennigs per kilometre (0·81*d.* per mile). In the case of small undertakings, where the pay is less, say 100 marks (£5) per month all included, and with a speed of say 15 kilometres (9·3 miles) per hour, the cost is 3·5 pfennigs per kilometre (0·68*d.* per mile).

The only way in which a saving can be effected is by adopting the system of money drop-in boxes, and that only when the driver can spare some of his time to attend to it. But as such a case can hardly occur except on country lines, where the driver has spare time, we must always count on a minimum expenditure of 5·5 to 6 pfennigs per kilometre (1·06*d.* to 1·16*d.* per mile).

In order to show how little small undertakings can sometimes utilize their staff, we will quote the following instances :

Dettmannsdorf. — Mr. Bach, secretary of railways, of Schwerin, in a report reproduced in the *Zeitung des Vereins deutscher Eisenbahnverwaltungen*, gives 2,868·13 marks (£143.8*s.* 1·6*d.*) as the pay of two drivers, travelling expenses, uniforms, etc., for an annual mileage (two cars) of 22,771 kilometres (14,149 miles). At least 2,700 marks (£135) of this are no doubt the pay of the two drivers. This is very little; nevertheless it amounts to 11·9 pfennigs per kilometre (2·30*d.* per mile), as the distance run per car is only about 950 kilometres (590 miles) per month. There are no conductors.

Sonthofen. — The expenditure on working staff was 2,707·96 marks (£135.7*s.* 11·5*d.*) during five months; passenger car mileage, 19,744 kilometres (12,269 miles); goods van mileage, 3,897 kilometres (2,422 miles). The cost is thus 11·5 pfennigs per kilometre (2·22*d.* per mile). In this case also there are no conductors; at least under the heading : " Staff " drivers only are mentioned. These receive, per day, 2·5 to 4 marks (2*s.* 6*d.* to 4*s.*) (according to seniority) as pay, 8 pfennigs (0·96*d.*) as travelling allowance and 1·3 pfennigs as premium per kilometre (0·25*d.* per mile). (These are the rates of pay of first and second class engine drivers on the State Railway.)

Partenkirchen. — 4,444·8 marks (£222.4*s.* 9·6*d.*) were expended (1) on wages, salaries, premiums, moving expenses and insurance as by law established, for a mileage of 33,712 kilometres (20,948 miles); that is 13·2 pfennigs per kilometre (2·55*d.* per mile). In this case also there are no conductors. The service is carried out and the maintenance is attended to by one head driver, two drivers, one reserve driver and one cleaner. The maintenance wages do not seem to be included in the 4,444·8 marks (£222.4*s.* 9·6*d.*) mentioned above, for they are given subsequently separately, and amount to 2,015·47 marks (£100.15*s.* 5·6*d.*), that is 5·98 pfennigs per kilometre (1·15*d.* per mile). The same remark applies to the figures concerning Dettmannsdorf and Sonthofen, given above.

In London in autumn 1905, the drivers were paid 8*d.* per hour, or 6*s.* per day for a day of 9 hours; in other cases, the pays was 42*s.* per week. In June 1906 drivers, according to their statements, were paid 7*s.* to 8*s.* per day.

Messrs. Alb. Janssen and d'Hoop, of the Brussels tramways, who in autumn went to London on a journey of enquiry, found that the cost of driver and conductor was 12·5 pfennigs per kilometre (2·41*d.* per mile).

At Berlin, the drivers of the General Omnibus Company say they receive 120 marks (£6) per month, plus uniform; this represents a total of about 140 marks (£7) per month. On the Friedrichstrasse line, assuming 27 working days in the month and 10 double journeys of 5·43 kilometres (3·37 miles), the monthly mileage is 2,932 kilometres (1,822 miles). The cost is therefore 4·78 pfennigs per kilometre (0·92*d.* per mile). The net working time is 10 × 2 × 23 = 460 minutes = 7 hours 40 minutes. The pay of the conductors, according te their own statement, is 90 marks (£4.10*s.*) per month. The total expenditure for each is therefore about 105 marks (£5.5*s.*) per month; or taking the same mileage as in the case of the drivers, 3·58 pfennigs per kilometre (0·69*d.* per mile).

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(1) It is possible that this sum includes initial expenditure which will be saved in the future.

Thus the driver and conductor together cost 8·36 pfennigs per kilometre (1·61*d.* per mile). This low figure is chiefly due to the great mileage, which tramway experience shows cannot be attained everywhere.

The preceding information as to the results in current practice, shows that the cost of driving depends mainly on the mileage. It also shows that small concerns cannot utilize their staff properly, and that in spite of moderate rates of pay, their staff sometimes costs more per mile than in large concerns.

3. *Supervision.* — Tramway figures show that from 0·5 to 1 pfennig per kilometre (0·1*d.* to 0·19*d.* per mile) may be allowed for the expenses under this head.

4. *Consumption of petrol.* — The consumption appears to depend approximately on the weight of the car, according to the results hitherto obtained.

The cars of the Sonthofen-Hindelang line, not much used by the public, weigh 4·5 tons and have consumed 12·27 pfennigs per kilometre (2·37*d.* per mile) on a bad mountain road; the 3·9 ton cars of the Dettmannsdorf-Marlow line have consumed about 13 pfennigs per kilometre (2·51*d.* per mile) on a good level road; the 1·9 ton cars, fairly well utilized, of the Kochel-Partenkirchen line, about 7·5 pfennigs per kilometre (1·45*d.* per mile) (254·32 grams per kilometre or 187 grams per horse-power hour [231 drams per mile or 107 drams per English horse-power hour]). All these figures are based on a cost price of 28 to 29 pfennigs per kilogram (5·40*d* to 5·60*d.* per lb.) of petrol.

The car builders themselves state that this cost under Berlin conditions, is 13 pfennigs per kilometre (2·51*d.* per mile), which corresponds to 0·45 kilogram per kilometre (1·587 lb. per mile) for cars weighing about 4 tons (1).

These figures tend to show that the consumption of petrol may be rather lower in countries which are really hilly, and this no doubt is due to the fact that the petrol supply to the cylinders can be cut off during a considerable part of the journey; for instance on the Kochel-Partenkirchen line, sometimes 5 kilometres (3 miles) and more are run without petrol. No doubt the same happens on the Sonthofen-Hindelang line, where conditions are similar.

It is true that the motor buses in London spend less for power because petrol is much cheaper there. Messrs. Janssen and d'Hoop record that in England 3·5 to 3·8 miles were run per gallon, *i. e.* 0·5 to 0·55 kilogram per kilometre. This, when petrol costs 7*d.* per gallon or 19·5 pfennigs per kilogram, represents an expenditure of 9·5 to 10·4 pfennigs per kilometre (1·83*d.* to 2*d.* per mile). The author obtained the same figures.

On the other hand, some motor bus companies give the cost of petrol as 5 pfennigs per kilometre (0·97*d.* per mile) for a car weighing 4 tons. We are not able to explain the cause of this difference.

5. *Consumption of oil, grease, glycerine, and the lighting of the cars.* — The Dettmannsdorf line expends under this head 3 to 3·25, the Sonthofen line 2·8 to 3 pfennigs per kilo-

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(1) Just as we are going to press, we hear that 36 pfennigs per kilometre (6·95*d.* per mile) are specified in larger contracts.

metre (respectively 0·58*d.* to 0·63*d.* and 0·54*d.* to 0·58*d.* per mile). The Partenkirchen live, having a summer service, only uses only grease; cost 0·75 pfennig per kilometre (0·14*d.* per mile), with cars weighing 1·9 tons (10 grams per kilometre [9·08 drams per mile]).

6. *Rubber tires.* — The life of a set of tires for a car amounts to from 15,000 to 20,000 kilometres (9,320 to 12,400 miles), if the paving is kept in good condition, and if the dimensions of the tires are correct; great importance is now attached to the latter condition. The upper limit applies to paving of the best quality, such as wood, asphalt, stone on a concrete foundation; the lower to paving of other kinds, according to quality.

At Partenkirchen, the life of the back tires is about 15,000 kilometres (9,320 miles), and of the front tires about 20,000 kilometres (12,400 miles); the cost of the two pairs of tires being in the ratio of 5 to 2, the mean is 16,400 kilometres (10,200 miles). The cost per set is 1,800 marks (£90); that is 11 pfennigs per kilometre (2·12*d.* per mile), with a tare of 1·9 tons and a good mountain road.

At Dettmannsdorf, the back tires costing 1,570 marks (£78.10*s.*) had a life of about 11,500 kilometres (7,150 miles), which corresponds to an expenditure of 13·75 pfennigs per kilometre (2·66*d.* per mile). The results obtained up to the present show that the probable life of the front tires will be 22,000 or 23,000 kilometres (13,670 or 14,290 miles); this gives 2·8 pfennigs per kilometre (0·54*d.* per mile), the cost price being 650 marks (£32.10*s.*). The total cost of tires is thus 16·5 pfennigs per kilometre (3·19*d.* per mile). After a little less than two years' working, the management estimates the cost at about 17 pfennigs per kilometre (3·28*d.* per mile), that is to say, at nearly the same figures as that for the first year.

At Sonthofen, a set of tires has a life of 18,000 kilometres (11,180 miles).

The guarantees of tire manufacturers, for tires costing 2,550 marks (£127.10*s.*) for vehicles weighing about 4 tons and running in large towns, varied last spring between 18,000 and 23,000 kilometres (between 11,180 and 14,290 miles).

It is however to be noted that the upper limit was only guaranteed for comparatively few vehicles; as soon as it was a question of a larger number and a longer time, manufacturers refused to give any such guarantee; if new orders had been given the time limit would also probably have been reduced. In some other cases a guarantee of 15,000 kilometres (9,320 miles) was given.

The long lives guaranteed were for Berlin with its generally excellent roads (much asphalt). Assuming the cost price of 2,550 marks (£127.10*s.*) we obtain the following cost per kilometre :

For a life of 15,000	kilometres	(9,320 miles).	17·0	pfennigs (1)	(3·28*d.*	per mile).
— — 16,000	—	(9,940 —).	15·9	—	(3·07*d.*	—).
— — 17,000	—	(10,560 —).	15·0	—	(2·90*d.*	—).
— — 18,000	—	(11,180 —).	14·2	—	(2·74*d.*	—).
— — 19,000	—	(11,800 —).	13·4	—	(2·59*d.*	—).
— — 20,000	—	(12,400 —).	12·8	—	(2·47*d.*	—).

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(1) Just as we are going to press, we hear that manufacturers refuse to guarantee tires for more than 15,000 kilometres (9,320 miles), and ask to be relieved from the longer guarantees given.

For a life of 21,000 kilometres (13,050 miles). . . . . 12·1 pfennigs (2·34*d.* per mile).
— — 22,000 — (13,670 —). . . . . 11·6 — (2·24*d.* —).
— — 23,000 — (14,298 —). . . . . 11·1 — (2·14*d.* —).

In London where there is much excellent wood paving, in 1905 the figure of 2*d.* per mile still prevailed, equal to about 10 pfennigs per kilometre.

In this connection, it may be mentioned that during the discussion of Mr. Manville's paper, one of the speakers, who is closely connected with motor bus building, remarked that manufacturers had incurred losses, but that the experience gained now enabled them to avoid such. We were unable to ascertain if the price of rubber is perhaps lower in England. It is possible that this figure, low as compared with that prevailing in Germany, is due to the very good quality of the wood paving, so that there is hardly any skidding. The vehicles there weigh about 4 tons.

The German Daimler Company has informed the author that tires of adequate size have a life of 20,000 kilometres (12,400 miles).

7. *Cost of maintenance of cars.* — The life of a car is very dependent on the system of maintenance adopted; this is the truer the more complicated the mechanism. Careful maintenance, the repair of any defect as soon as discovered, prevents any injurious action which a defective part can have on the parts adjoining, or even on the whole of the mechanism; it costs more, but on the other hand, it lengthens the life.

At Partenkirchen, the expenditure for this item, for cars weighing 1·9 tons, was 16 pfennigs per kilometre (3·09*d.* per mile); and they were very particular as to the proper appearance of the cars. Wages by themselves amounted to 2,015 marks (£100.15*s.*), for 33,712 kilometres (20,948 miles); that is 5·98 pfennigs per kilometre (1·15*d.* per mile). These figures apply to the first 11,000 kilometres (6,800 miles) of each vehicle, and it is therefore hardly probable that they will become reduced in the future.

At Sonthofen, the expenditure during the first five months of the service was 7 pfennigs per kilometre (1·35*d.* per mile); the mileage was 19,744 kilometres (12,269 miles) by buses and 3,897 kilometres (2,422 miles) by vans. Nevertheless, according to the report of an expert, the cars were already in less good condition ten months after the service started. The roads being bad, it is clear that maintenance was not sufficiently carefully attended to.

At Dettmannsdorf, the expenditure during the first twelve months was 10·9 pfennigs per kilometre (2·10*d.* per mile). It was then hoped that it would be possible to reduce one of the causes of rapid wear, namely the insufficient protection against the entrance of dust and other foreign bodies from below, by means of casings, etc. The expected saving, however, does not appear to be large enough to counterbalance the cost of repairs, which grew with age, as the management states at the end of the second year's working that these cost 12 pfennigs per kilometre (2·32*d.* per mile). In London, in the winter of 1905-1906, builders and bus companies gave the figure of 10 pfennigs per kilometre (1·93*d.* per mile); this figure is said to have been obtained with buses up to eighteen months old (1).

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(1) Experts in London conclude from the experience gained, that the proper organization of maintenance is not possible unless there are at least 40 buses together at one depot. The following system has been developed: in a case given as instance, the buses are divided into groups of 8 in a depot where there

8. *Insurance.* — The premium required for the insurance of cars and depots against fire, seeing the risks connected with petrol, is 10 per mil. Assuming that a car cost 20,000 marks (£1,000), that its annual mileage is about 50,000 kilometres (31,000 miles), and that the cost of the depots, etc., is 5,000 marks (£250) per car, the cost of insurance comes to about 0·50 pfennigs per kilometre (0·10*d.* per mile).

Insurance against accidents costs at least 0·5 per cent of the receipts. If the latter amount to 50 pfennigs per kilometre (9·66*d.* per mile), this item will be 0·25 pfennig per kilometre (0·05*d.* per mile). The total insurance thus comes to 0·75 pfennig per kilometre (0·14*d.* per mile).

9. *Life of a car.* — At the present time, the more modern types have hardly been in use two years; therefore it is not possible to determine this very important problem except from the point of view of probability. The German manufacturers at present state that the life will be eight to ten years, but practical experience is against this.

In London, the bus owners themselves hardly venture to assert that the life is five years. Engineers who state that they are not interested parties, estimate the life at three years when the reserve is small and at four years if it is large.

Some London experts who in February, 1906, still considered as reasonable an estimated life of five years, have already reduced their estimate to three or four years, on the basis of the results obtained in a short period, up to June. This is however not to say that the cars will no longer be able to run; the reduction in the effective life is on the contrary based on the consideration that inside two years, when motor buses on roads will be in the majority, the authorities will be more particular than today with respect to quiet running, and that a noisy car will no longer attract the public, so that the owner will of himself no longer want to run it. Owing to the actual requirements, as to comfort of the passengers, the latter reason will induce the owner, sooner than any orders of the authorities, to withdraw a car.

We can sum up these estimates, based on the annual runs of a number of cars, by stating that a vehicle, together with its body, running on good roads and properly maintained, will have a total life of 200,000 kilometres (124,000 miles), or of four years, if 50,000 kilometres (31,000 miles) are run per year. It is possible that a very strongly built body will have a somewhat longer life. The same remark applies to the whole of the car, if conditions are exceptional so that increase of noise, etc., can be neglected.

The estimate of 200,000 kilometres (124,000 miles) represents no doubt a maximum which will only be attained with a proper reserve and on good raods, and when there is careful and well-organized maintenance. If the prime cost of the car is 18,000 marks (£900) (tires excluded), this life of 200,000 kilometres (124,000 miles) corresponds to a cost of 9 pfennigs per kilometre (1·74*d.* per mile). The maintenance and the redemption, which are closely connected, probably do not under any conditions amount to less than

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are 69 buses; the maintenance staff is also divided into 8 gangs, each assigned to and attending to only one group of buses. The work is divided in each gang, so that for instance, the man who attends to the motor proper has nothing to do with the couplings or transmissions. All the different parts of all the buses are not examined every day, but every second or at the outside every third day. If any defect is discovered while the bus is out, the man who has to attend to the damaged part is sent for at once.

20 pfennigs per kilometre (3·86*d.* per mile) in the case of a car costing 18,000 marks (£900).

Among the German undertakings here considered, Dettmannsdorf, after the service had been operated nearly eighteen months, estimated the life of the mechanism, costing 14,000 marks (£700) per car, at seven years (say, at 11,500 kilometres [7,150 miles] per year, 80,000 kilometres [50,000 miles] in round figures) and that of the chassis and body, costing 6,000 marks (£300), at about double that length; in this way the redemption per year is calculated at 2,550 marks (£127.10*s.*) per car. Taking the annual mileage on this line into consideration, this corresponds to 22·2 pfennigs per kilometre (4·29*d.* per mile). The actual cost of repairs being 12 pfennigs per kilometre (2·32*d.* per mile), the total cost of properly keeping up the car stock is 34 pfennigs per kilometre (6·57*d.* per mile).

At Partenkirchen, amortization at 20 per cent has been provisionally adopted, representing, with an annual mileage of 11,000 kilometres (6,800 miles) per car, a life of 55,000 kilometres (34,000 miles). The cost of a car being 16,500 marks (£825), this gives 30 pfennigs per kilometre (5·79*d.* per mile). It must however be noted, that this is a provisional estimate, and the report nowhere states if the condiition of the cars justifies this high figure. It is true that this undertaking is able, financially, to accept this amortization as correct. The receipts have been 3·38 marks (3*s.* 4·56*d.*) per passenger, 16 pfennigs per passenger-kilometre (3·09*d.* per passenger-mile) and 1·04 marks per car-kilometre (1*s.* 8·08*d.* per car-mile). The total was 33,712 car-kilometres (20,948 car-miles) and 224,209 passenger-kilometres (139,320 passenger-miles). The mean number of passengers per car has thus been 6·7, and the utilization, as the cars can take 14 passengers, 48 per cent. The capital invested is taken at 4 per cent.

These two instances show that for the moment it is advisable to limit oneself to the conclusion that the 200,000 kilometre (124,000 mile) life mentioned is in reality a maximum which can only be obtained under favourable conditions and with careful maintenance.

Another important question is the mileage a car can make in a year, and closely connected therewith is the number of reserve cars required.

Information on these two points can only be sought for in England, as the German undertakings are at present too few in number, of too small importance, and only utilize their stock to a small extent.

The statements made by manufacturers are quite unworthy of belief; still less can any reliance be placed on the statements made, during the discussion of Mr. Manville's paper, by some of those interested in the motor bus industry. German makers of the best class state that for every six cars running there should be 1 in reserve.

In what follows, we mean by reserve the proportion of vehicles there must be over and above the maximum number required for the normal weekday service, so as to make it possible, without disturbing the time-tables on the working days, to do what repairs are necessary beyond what can be effected during the night.

It is necessary that the reserve, in the case of both tramways and motor buses, should satisfy the two following conditions : strictly keeping to the time-table during working hours, and maintaining the cars properly. In England, this has so far not been the case. The time-table on weekdays is looked upon as a maximum service, and when important repairs become necessary, the service is correspondingly reduced. Under such conditions, the working is evidently more profitable at first, when the cars are new, but the future has to pay for it. This explains to some extent the 10 to 20 per cent dividends paid during the year by some of the London concerns (1). The statement made during the discussion several times referred to, that « London bus companies prefer to have all cars on the road earning money » describes the system adopted in London, which however evidently cannot survive in the long run.

In order that motor buses may compete for public traffic, they must, just like tramways, satisfy this initial condition : the time-table must be kept to. In this connection, several instructive examples, which occurred in the current practice, were mentioned in London.

Mr. Schenk, director of several tramway and motor bus companies, stated that at Birmingham it was difficult to keep a 10 car service going with 24 cars, of first class make and on the average twelve months old; that it was tried to increase this to a 12 car service but without success. The same speaker read out a table drawn up by an engineer connected with car building, showing that the average performance of a London motor bus is 120 miles per day and 30,000 miles per year.

The case of Birmingham, with 14 reserve cars for 10 cars running, shows a 140 per cent reserve; that for London gives

$$100 \times \frac{120 \times 365}{30,000} - 100 = 46 \text{ per cent.}$$

It is possible that the high figures of Birmingham are partly due to the gradients and to the quality of the paving, and partly perhaps to the fact that at first the maintenance of the cars was rather neglected. We therefore attach no great imporance to them.

On the other hand, the information concerning London may be considered correct; it gives the average for several hundred cars. Moreover, it is strongly confirmed by the results obtained in tramways. Our smallest tramways have found that a reserve of 25 to 33 per cent was ample; in a medium size undertaking, the proportion is 12 to 20 per cent, and in a large size one, as little as 8 per cent. As the London undertakings, as at present existing, may be considered as of medium size in the sense in which we use this word in the case of tramways (up to about 150 cars), 46 per cent would represent about 2 1/2 to 3 times as much reserve as would be required in the case of a tramway of similar importance. This figure is easily explained by the greater complexity of the mechanism.

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(1) Let us here make a few remarks on the subject, several times referred to, of the large dividends distributed last year by some of the London motor bus companies. It is stated that these dividends of from 10 to 20 per cent were possible because the total expenditure (redemption included) was 38 to 45 pfennigs per kilometre (7·34 to 8·69*d.* per mile), whereas the receipts were 55 to 65 pfennigs per kilometre (10·62 to 12·55*d.* per mile). The following items are lower in England than in Germany : petrol (stated to be 5 pfennigs [0·97*d.* per mile]), 8 pfennigs (1·54*d.*) less; rubber (10 pfennigs [1·93*d.* per mile]), 4 pfennigs (0·77*d.*) less; repairs (7·5 pfennigs [1·45*d.* per mile], as the cars are quite new), about 3·5 pfennigs (0·68*d.*) less. Finally, the new cars at first ran 208 kilometres (129 miles) in the day, and their utilization was very high; according to the reports issued by the managements during whole weeks, 91 and 96 per cent of the total rolling stock were at work. If any car was damaged, there were so many fewer journeys. At that time the life of a car was still assumed to be eight years. Some days after these excellent dividends had been declared, there were new issues. In 1905, the London motor buses conveyed about 900 passengers per car per day, at fares of from 1*d.* to 3*d.*

Similarly, the correctness of the London figures, as to daily run, allowing for the conditions in a big city, may be fully admitted : *i. e.* 120 miles per day, corresponding to a seventeen hour service at an average speed of about 11 to 11·5 kilometres (6·8 to 7·1 miles) per hour, stops at terminals included. The annual mileage of 48,000 kilometres (29,800 miles), in round figures, obtained in London, agrees sufficiently well with the average performance of mechanical tramway cars in Germany. The latter varies between 42,000 kilometres (26,000 miles) on the smaller lines and 55,000 (34,000 miles) on the important ones; in some cases, it amounts to 60,000 kilometres (37,300 miles).

Finally, the cost of a car depot may well be estimated at 6,000 marks (£300) per car; this includes cost of land, workshops and fittings, offices and furniture, uniforms and cash in hand necessary.

The preceding figures show that the capital expenditure and working expenses required for a town service, of 1 million car-kilometres (621,400 car-miles) per year, are as shown in the following table.

For an annual mileage of 48,000 kilometres (29,800 miles) per car, twenty-one cars are required, of which fifteen are actually running at the same time (the reserve is accordingly 40 per cent). The performance of each car per day is then

$$\frac{1{,}000{,}000}{15 \times 365} = 183 \text{ kilometres (113 miles) approximately.}$$

If the cars have outside seats, so that they can carry thirty-four passengers, the cost per seat per kilometre is thus $\frac{65{\cdot}86}{4} = 1{\cdot}94$ pfennigs (0·37*d.* per mile). If we assume the utilization to be 30 per cent (this, according to tramway experience, is a high figure for such a large vehicle, except in very large towns), the cost per passenger-kilometre is 6·46 pfennigs (1·25*d.* per passenger-mile).

This figure must, on the other hand, represent the cost of the ticket, in order that the dividend may be 4 per cent. A journey of 1·5 kilometre (0·93 mile) would thus cost 10 pfennigs (1·2*d.*), one of 3 kilometres (1·86 mile), 20 pfennigs (2·4*d.*), and so on. Evidently under these conditions, a halfpenny rate it quite out of the question, and so are the season tickets now usual. The average cost of the journey, per passenger, assuming four passengers per car-kilometre (a utilization frequently recorded on tramways), would be $\frac{65{\cdot}86}{4} = 16{\cdot}47$ pfennigs (1·98*d.*) (1).

The corresponding total expenses of tramways, in towns of medium importance and in very large cities, have during the last few years amounted to from 24 to 37 pfennigs per kilometre (4·63*d.* to 7·15*d.* per mile) (2); this includes interest at 4 per cent on the total capital, a high figure for the sinking fund (as the concessions have only a short time to run), rent of the roads (in the form of taxation, up to 1·6 pfennigs [0·19*d.*] per passenger), maintenance of the paving and a considerable allowance for accidents. The amount includes about 14 to 20 pfennigs (2·70*d.* to 3·86*d.* per mile) for working expenses proper; the rest is required for financial purposes, including taxation and redemption.

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(1) On tramways, this figure varies betweeu 8·2 and 11·5 pfennigs (between 0·98*d.* and 1·38*d.*)

(2) In these calculations, the motors and trailers are lumped together.

A. — CAPITAL EXPENDITURE.	Marks.	(£	s.)
21 cars at 18,000 marks (£900) each, tires not included.	378,000	18,900	0
21 sets of tires, at 2,550 marks (£127.10*s.*) per set . .	53,550	2,677	10
21 times 6,000 marks (£300) for depot, etc., and necessary cash in hand.	126,000	6,300	0
Total capital outlay. . .	557,550	27,877	10

B. — WORKING EXPENSES.	Pfennigs per kilometre.	(Pence per mile.)	Total in Marks.	(Total in £.)
General management	2·50	(0·48)	25,000	(1,250)
Drivers and conductors.	8·60	(1·66)	86,000	(4,300)
Supervision	0·70	(0·14)	7,000	(350)
Petrol.	13·00	(2·51)	130,000	(6,500)
Lubricants, glycerine and lighting.	3·00	(0·58)	30,000	(1,500)
Renewal of rubber tires.	14·00	(2·70)	140,000	(7,000)
Maintenance of cars.	11·00	(2·12)	110,000	(5,500)
Insurance.	0·75	(0·15)	7,500	(375)
Total working expenses. . .	53·55	(10·34)	355,500	(26,775)

C. — INTEREST AND SINKING FUND.	Pfennigs.	(Deniers.)	Marcs.	(£	s.)
Interest 4 per cent, sinking fund 1 per cent	2·79	(0·54)	27,878	(1,393	18)
Cars, depreciation (tires not included), at 18,000 marks (£900) per 200,000 kilometres (124,000 miles) . .	9·00	(1·74)	90,000	(4,500	0)
Buildings, maintenance and depreciation, 1·5 per cent of 80,000 marks (£4,000)	0·12	(0·02)	1,200	(60	0)
Tools and other appliances, depreciation, 16 per cent of 25,000 marks (£1,250)	0·40	(0·08)	4,000	(200	0)
Total required for interest and sinking fund. .	12·31	(2·38)	123,078	(6,153	18)

SUMMARY (1).	Pfennigs.	(Deniers.)	Marcs.	(£	s.)
Working expenses	53·55	(10·34)	535,500	(26,775	0)
Interest and sinking fund	12·31	(2·38)	123,078	(6,153	18)
Total. . .	65.86	(12·72)	658,578	(32,928	18)

(1) The following estimate, drawn up by one of our chief motor bus builders, may be of interest.

Probable results of a town bus service.

Rolling stock required : 6 motor buses, 38 passengers each, and 1 bus as reserve. Service, from 6 a. m. to midnight. With 6 buses running 18 hours, the mileage will be 200 × 6 × 365 = 438,000 kilometres (272,165 miles) per year. With a mean utilization of 75 per cent this will give per year 438,000 × 38 × 0·75 = 12,483,000 passenger-kilometres (7,756,700 passenger-miles).

A. — CAPITAL EXPENDITURE.	
7 buses, at 16,700 marks (£835) each	116,900 marks (£5,845. 0*s.*)
7 sets of tires at 2,550 marks (£127.10*s.*) per set	17,850 — (£892.10*s.*)
Total. . .	134,750 marks (£6,737.10*s.*)

B. — WORKING EXPENSES.	Marks.	(£	s.)		Pfennigs.	(Pence per mile.)
1. Interest at 4 per cent on 134,750 marks (£6,737.10*s.*)	5,390	(269	10),	or	1·23	(0·24)
2 and 3. Repairs and depreciation, at 15 per cent on 116,900 marks (£5,845)	17,535	(876	15),	—	4·00	(0·77)
4*a*. Pay of 12 drivers : 12 × 1,200 marks (12 × £60).	14,400	(720	0)	—	5·92	(1·14)
4*b*. — 9 conductors 9 × 365 × 3·50 marks (9 × 365 × 3*s*. 6*d*.) . . .	11,497	(574	17)			
5. Rent of depot	1,400	(70	0),	—	0·32	(0·06)
6. Insurance, 1 per cent on 115,500 marks (£5,775) (6 buses)	1,155	(57	15),	—	0·26	(0·05)
7. Lubrication and cleaning, 200 marks (£10) per bus.	1,200	(60	0),	—	0·27	(0·052)
8. New rubber tires, 18 sets (3 per bus).	45,900	(2,295	0),	—	10·48	(2·02)
9. Petrol : per bus, 18 hours at 5 kilograms (11·02 lb.) = 90 kilograms (198·4 lb.) per day; 365 days, 6 buses, 26 pfennigs par kilogram (1·42*d*. per lb.)	51,246	(2,562	6),	—	11·70	(2·26)
Total. . .	149,723	(7,486	3),	or	34·18	(6·592)

The working expenses per passenger-kilometre are thus $\frac{14{,}972{,}300}{12{,}483{,}000}$ = 1·19 pfennig (0·23*d*. per passenger-mile).

The higher figures apply to large cities where taxation, maintenance of paving and depreciation are higher.

The passenger-kilometre costs, on the same assumptions as those made in the case of the motor bus (average utilization, 30 per cent of the thirty-four seats, or an average of 11 1/3 passengers per car), $\frac{24 \text{ to } 37}{11\,{}^{1}/_{3}} = 2{\cdot}12$ to 3·27 pfennigs (0·41*d.* to 0·63*d.* per passenger-mile), as against the 6·46 pfennigs (1·25*d.*) of the motor bus. The moter bus cost is thus, in medium-sized towns, about 3 times, and in the largest towns 1·8 to 2 times, that of tramways.

In the case of a car service in the country with open vehicles weighing 1·9 tons and having 14 seats (as at Partenkirchen), the following minimum expenditure would have to be allowed for :

Length of trip : 12 kilometres (7·5 miles). Bus starting every two hours, every hour and every forty minutes; daily service from 5 am to 9 pm; thus giving 70,000, 140,000 and 210,000 car-kilometres (43,500, 87,000 and 130,500 car-miles) per year (*see* table I).

The seat-kilometre thus costs $\frac{58{\cdot}39 \text{ or } 54{\cdot}85 \text{ or } 53{\cdot}78}{14} = 4{\cdot}17$ or 3·92 or 3·84 pfennigs (0·81*d.* or 0·76*d.* or 0·74*d.* per seat-mile), and the passenger-kilometre, on the optimistic assumption of a mean utilization of 50 per cent, 8·3 or 7·8 or 7·7 pfennigs (1·60*d.* or 1·51*d.* or 1·49*d.* per passenger-mile). Rounding this off to 8 pfennigs (1·54*d.* per passenger-mile), the fares would therefore have to be :

For 1·25 kilometres (0·78 mile)	10 pfennigs (1·20*d.*).
— 1·88 — (1·17 —)	15 — (1·80*d.*).
— 2·50 — (1.55 —)	20 — (2·40*d.*),

On very small tramways and rural lines, the car-kilometre during recent years has cost between 24 and 40 pfennigs (between 4·63*d.* and 7·72*d.* per car-mile), including depreciation, redemption and interest at 4 per cent (¹). The passenger-kilometre, assuming the average number of 7 passengers (in the case of the usual motor bus service we have also assumed 7 passengers = 50 per cent of the 14 seats) in this case therefore costs $\frac{24 \text{ to } 40}{7} = 3{\cdot}43$ to 5·71 pfennigs (0·66*d.* to 1·10*d.* per passenger-mile). In this case also, the motor bus service is 1·45 to 2·3 times more costly. If we extend this comparative calculation, we find that it is only when the interval between successive cars is longer than two hours that the motor bus becomes cheaper than the electric tramway (somewhere about 60 pfennigs per car-kilometre [11.59*d.* per car-mile]).

Now considering this high cost, we are led to enquire what are the merits which a modern motor bus service possesses, as compared with town and rural tramways, which from the financial point of view justify its introduction.

(¹) In some exceptionally unfavourable cases, the figure has been 50 pfennigs (9·66*d.* per car-mile); these we will not take into consideration in our comparisons.

Table I.

—	70,000 *car-kilometres* (*13,500 car-miles*).		110,000 *car-kilometres* (*87,000 car-miles*).		210,000 *car-kilometres* (*130,500 car-miles*).	
	Cost per kilometre, in pfennigs (in pence per mile).	Total cost.	Cost per kilometre, in pfennigs (in pence per mile).	Total cost.	Cost per kilometre, in pfennigs (in pence per mile).	Total cost.
A. — CAPITAL EXPENDITURE.						
		Marks. (£)		Marks. (£)		Marks. (£)
2 cars (1 as reserve), 3 cars (1 as reserve) and 5 cars (2 as reserve), at 15,000 marks (£750) each, tires not included	...	30,000 (1,500)	...	45,000 (2,250)	...	75,000 (3,750)
2, 3 and 5 sets of tires, at 1,800 marks (£90) per set.	...	3,600 (180)	...	5,400 (270)	...	9,000 (450)
Depot, offices and workshops, land included. .	...	14,000 (700)	...	15,000 (750)	...	17,000 (850)
Tools in workshops	...	5,000 (250)	...	6,000 (300)	...	7,000 (350)
Sundries and necessary cash in hand	...	5,400 (270)	...	5,600 (280)	...	7,000 (350)
Total, heading *A*	...	58,000 (2,900)	...	77,000 (3,850)	...	115,000 (5,750)
B. — WORKING EXPENSES.						
		Marks. (£ *s.*)		Marks. (£ *s.*)		Marks. (£ *s.*)
Cost of management, including stationery and law expenses	4·3 (0·83)	3,000 (150 0)	2·7 (0·52)	3,800 (190 0)	1·9 (0·37)	4,000 (200 0)
Pay and allowances of 2, 4 and 6 drivers, at 1,500 marks (£75) each.	4·3 (0·83)	3,000 (150 0)	4·3 (0·83)	6,000 (300 0)	4·3 (0·83)	9,000 (450 0)
Petrol, at 29 pfennigs per kilogram (1·58*d.* per lb.).	7·5 (1·45)	5,250 (262 10)	7·5 (1·45)	10,500 (525 0)	7·5 (1·45)	15,750 (787 10)
Maintenance of buses	12·0 (2·32)	8,400 (420 0)	12·0 (2·32)	16,800 (840 0)	12·0 (2·32)	25,200 (1,260 0)
Lubrication, glycerine and lighting	3·0 (0·58)	2,100 (105 0)	3·0 (0·58)	4,200 (210 0)	3·0 (0·58)	6,300 (315 0)
Wear of rubber tires, at 1,800 marks (£90) per 16,400 kilometres (10,190 miles)	11·0 (2·12)	7,700 (385 0)	11·0 (2·12)	15,400 (770 0)	11·0 (2·12)	23,100 (1,155 0)
Fire and accident insurance	0·75 (0·14)	525 (26 5)	0·75 (0·14)	1,050 (52 10)	0·75 (0·14)	1,575 (78 15)
Total, heading *B*	42·82 (8·27)	29,975 (1,498 15)	41·25 (7·96)	57,750 (2,887 10)	40·44 (7·81)	84,925 (4,246 5)
C. — INTEREST AND SINKING FUND.						
		Marks. (£ *s.*)		Marks. (£ *s.*)		
Interest 4 per cent, sinking fund 1 per cent . .	4·1 (0·79)	2,900 (145 0)	2·7 (0·52)	3,850 (192 10)	2·7 (0·52)	5,750 (287 10)
Cars, depreciation, at 15,000 marks (£750) per 150,000 kilometres (93,200 miles)	10·0 (1·93)	7,000 (350 0)	10·0 (1·93)	14,000 (700 0)	10·0 (1·93)	21,000 (1,050 0)
Buildings, depreciation	0·3 (0·06)	200 (10 0)	0·2 (0·04)	230 (11 10)	0·2 (0·04)	250 (12 10)
Tools, depreciation	1·1 (0·21)	800 (40 0)	0·7 (0·14)	960 (48 0)	0·5 (0·10)	1,020 (51 0)
Total, heading *C*	15·57 (3·01)	10,900 (545 0)	13·60 (2·63)	19,040 (952 0)	13·34 (2·58)	28,020 (1,401 0)
Total, heading *B*	42·82 (8·27)	29,975 (1,498 15)	41·25 (7·96)	57,750 (2,887 10)	40·44 (7·81)	84,925 (4,246 5)
Grand total, *B* and *C*. . .	58·39 (11·28)	40,875 (2,043 15)	54·85 (10·59)	76,790 (3,839 10)	53·78 (10·39)	112,945 (5,647 5)

Mr. Manville's report enumerates the following advantages and disadvantages of the motor bus :

Disadvantages :

1° High working expenses ;
2° Noisy running, inconveniencing passengers, the public and the neighbourhood ;
3° Smell ;
4° Dufficulty of driving on greasy roads ;
5° Risk of fire ;
6° Defective springing ;
7° Danger to other road vehicles ;
8° Unreliability.

Advantages :

1° Greater speed, as able to thread their way through traffic ;
2° Possibilty of shifting service from one road to another, so as to find the most profitable route ;
3° Possibility of taking up and setting down passengers at the side of the footway ;
4° Absence of rails in the roadway ;
5° Ease of running in narrow streets.

Among the disadvantages, it is only necessary to consider those given under 1°, 6° and 8° ; as for the others, we may admit that they are partly present also in tramways, and that progress in technical science will soon reduce them or make them disappear.

The high working expenses have already been considered above. Defective, too stiff springing, is really a very disagreeable disadvantage which is always in evidence except on a very well-kept road, and which, where tramway competition exists, induces many possible customers to patronize the tramways. This disadvantage might be materially reduced by the use of pneumatic instead of solid tires, but as yet it has been impossible to construct pneumatic tires capable of standing such heavy loads. Unreliability is a disadvantage which is still of much importance, and quite apart from being a nuisance to the public and disturbing the service, makes it necessary to keep a reserve. There is no doubt that technical progress will reduce this disadvantage ; owing however to the complexity of the mechanism, the reliability of electric and steam railways will probably never be attained.

The advantages mentioned are more or less real, but except that given under 1°, they are not of much importance. Those mentioned under 3°, 4° and 5° can be neglected, because the conditions in question have never given rise to any appreciable inconvenience on tramways. Advantage 2°, the possibility of altering the route, may sometimes be of importance in very large towns. But already in towns with 500,000 inhabitants, or even less, what the traffic wants is so evident to the trained eye of the engineer who has studied the subject, that it is very rarely necessary to make any experiments.

On the other hand, the greater speed on town lines is an important advantage, all the more so as practical experience has shown that the difference is considerable on routes where there is very much traffic. At Berlin, on the Friedrichstrasse route, the motor buses attain a speed of 14 kilometres (8·7 miles) per hour, and in London, on the Piccadilly, Charing Cross, Tottenham Court Road, Oxford Street and Strand routes, one of 14 to 15 kilometres (8·7 to 9·3 miles) per hour. A tramway car would hardly exceed 10 kilometres (6·2 miles) per hour. The advantage is smaller in the less crowded streets in town and in the suburbs, where tramways readily attain a speed of about 12 to 13 kilometres (7·5 to 8 miles) per hour. On suburban lines, the tramway probably has the advantage, for as the paving is generally inferior, the motor bus can hardly exceed 15 kilometres (9·3 miles) per hour.

The time gained by the passenger thus depends on the nature of the route. If the very crowded section is long, the difference may become important and justify a higher fare. If the difference of speed is 4 kilometres (2·5 miles) per hour, the time saved on a journey of

1 kilometre (0·62 mile)	is 1·7 minute.
2 kilometres (1·24 —)	is 3·4 minutes.
4 — (2·5 —)	is 6·8 —

With a difference of speed of 2 kilometres (1·24 mile) per hour, the time saved on a 4 kilometre (2·5 mile) journey is only 3·4 minutes.

These figures show that a saving of time sufficient to justify a fare higher than that charged on the tramways, cannot be effected except in very large towns, where there are long roads very crowded. However, in such towns a higher fare could well be charged not only on such roads, but would also be justified for the other parts of the route, as the passenger would then not have to change into another conveyance.

This comparison shows, at the same time, that the only place, if any, where motor buses can be profitably used, is in the most crowded parts of very large cities having a population of 2 millions and upwards.

At first sight, this conclusion would seem in contradiction with the one enunciated above, that a rural service of motor buses is only more economical than a tramway, when the interval between successive cars is longer than two hours. This was based on a comparison with a modern electric tramway, carrying passengers only. Now given the high cost, it is not possible to operate a service on either system in districts where there is so little traffic, and make the receipts proper pay for it. Subsidies are therefore necessary, and these can only be obtained in two cases :

1° If it may be expected that the subsidies given at the start can be repaid out of future increases ;

2° If the undertaking really benefits the district concerned.

As regards 1°, table I shows that the cost of a motor bus service does not vary much with the annual mileage. With a service every forty minutes (210,000 kilometres [130,500 miles] per year), the kilometre costs not quite 8 per cent less than with a service every two hours (70,000 kilometres [43,500 miles] per year) ; the difference is only 58·39 — 53·78 = 4·61 pfennigs per kilometre (0·89*d.* per mile). The motor bus can therefore hardly reckon on a profit from the gradual reduction in the working expenses, but can only obtain it, solely and absolutely, by greater receipts per car-kilometre ; if such are lacking, it never can become profitable, even if the traffic grows very much. Now the results obtained on existing rural tramways and motor bus lines, show that a regular service, such as we are considering, cannot be expected to earn receipts of 58 pfennigs per kilometre (11·20*d.* per mile).

Matters are very different on a railway. The expenses become reduced (in cases of the kind we are considering) very materially as the traffic increases; the reduction may attain about 60 per cent (from 60 to 24 pfennigs [from 11·59*d.* to 4·63*d.* per mile]). The 36 pfennigs (6·96*d.*) saved can be utilized with advantage in reducing the fares, so as to stimulate the traffic, and in repaying the initial subsidies. It is from the very beginning unnecessary to base the tariff on the initially high expenditure as the expenses will certainly go down. Such is not the case with the motor bus, where the expenses will always be nearly the same. These remarks apply where there is passenger and luggage traffic only, like on suburban and excursion lines, as opposed to rural lines.

But a railway has also other advantages, which the motor bus entirely lacks : it can carry goods, and by doing so really improve the condition of the district concerned, and consequently justify subsidies even if it will never pay interest on the capital invested.

This brings us to 2°. This case often turns up in districts in the plains, particularly if agricultural. We cannot compare this case with that of an electric tramway, with passenger traffic only. Similarly a comparison with our *Kleinbahnen* (minor railways, light railways worked by steam power) would not be accurate, as the amount of traffic they can carry exceeds that a motor bus service can deal with by far too much. It would rather seem that owing to the small mileage of a motor bus, we should select for comparison a railway of the lowest order, for instance a strong military railway with petrol-driven railway motor cars, the track laid on an ordinary high road, and otherwise operated just like a steam railway (1).

Certainly this idea is not new, but it may perhaps be advisable to examine it a little more closely. Just as the motor bus can claim in its favour that it does not require a special track, (one great initial expense), so the petrol-driven railway motor car has the advantage, as regards capital outlay, of requiring neither a power station nor conductors.

The author, in making this comparison, by no means thinks of generally recommending this type of railway for rural traffic. He is of opinion that once it has been recognized that improvement is necessary, a light railway, except under very unfavourable conditions, well designed and constructed with a view to the future good of the traffic, is to be preferred. Experience shows that the growth of the traffic has generally been underestimated. The author examines the question in order to show that if it is absolutely necessary to have a low capacity transport system in a rural district and to spend money on it, it is better to have a light railway of the cheapest type than a motor bus service.

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(1) Economy in construction and operation make necessary a narrow-gauge track, motors with one cylinder, not heavy, and without transmissions through toothed gears. A 75 centimetre (2 ft. 5 $^1/_2$ in.) gauge would be suitable, both as regards cost of construction and working expenses, and as regards possible increase of traffic. The car should in our opinion be as follows :

Type of car : On two axles with springs, roof as on open tramway-cars, 12 seats at one end, space for luggage and produce at the other; in the middle compartment for driver, to drive car in either direction.

Motors : Two single-cylinder motors, each of 8 horse-power, running at a low number of revolutions per minute, each actuating one axle, the two axles being independent. Running backwards by throwing over the reversing gear, just as on steam lines.

Clutch and transmission : Friction clutch on main shaft; one gear (toothed wheels) to be used for starting and up to a speed of 5 to 8 kilometres (3·1 to 5 miles) per hour; then direct drive from shaft to sprocket wheel for maximum speed (second speed).

Tare, about 1·4 tons; weight in working order, with 13 passengers and 600 kilograms (1,320 lb.) of luggage and parcels, 3 tons. Ordinary running speed, 16 kilometres (9·9 miles) per hour; maximum speed, 24 kilometres (14·9 miles) per hour.

The calculations given below assume a district where the configuration of the country is favourable and the number of stopping places required is not great; we may at once state, that if the country is undulating, the cost of a railway will be greater than that given below, and that it is always possible to find special cases, especially where there are frequent and heavy snowfalls, where calculation would show that the motor bus gives somewhat unfavourable results.

The estimates for a railway of this kind may be approximately as follows :

Length of line, 12 kilometres (7·5 miles) ; service every two hours, every hour or every forty minutes, from 5 am to 9 pm, corresponding to 70,000 or 140,000 or 210,000 train-kilometres (43,500 or 87,000 or 130,500 train-miles) per year. Moreover, on working days, a goods wagon is coupled on during 2 or 3 or 4 double journeys, corresponding to 15,000 or 23,000 or 30,000 car-kilometres (9,320 or 14,290 or 18,640 car-miles) per year (*see* table II).

In table II, the expenses as well as the goods receipts are based, as far as possible, on actual practice. Nevertheless, the author would ask the reader for the moment to consider these figures only as proportional numbers showing the influence of goods traffic on passenger rates, the reduction of the expenses of a railway when there are more trains, and the immutability of the cost of a motor bus service.

It is true that the initial capital outlay for a motor bus service is only 58,000 marks (£2,900) as against 220,000 marks (£11,000) for the railway; but in accordance with what has been said above as to the results obtained by increasing the number of journeys, the railway can from the start base its passenger rates on an hourly service, that is to say, on 2·2 pfennigs per kilometre (0·42*d.* per mile), without much risk; moreover, it benefits by its service the district concerned. The motor bus, on the other hand, cannot go below 6·7 pfennigs per kilometre (1·29*d.* per mile), even if the traffic increases very much.

We have previously stated that in districts where there is very little traffic, the motor bus can never earn its total expenses, nor even its working expenses proper; the country people are not prepared to pay 10 pfennigs (1·20*d.*) for a journey of 1·5 kilometre (0·93 mile). Consequently, if the undertaking only has a short life, all the capital expended is lost (¹). The appreciable advantage of benefit to the district concerned is not even left.

With the railway, on the other hand, the passenger rate of 2·2 pfennigs per kilometre (0·42*d.* per mile), or say 10 pfennigs for 4·5 kilometres (1·20*d.* for 2·8 miles), is so low that it is sure to be patronized. Even if it does not pay in the long run, as against the capital outlay, there is always the permanent advantage of improved conditions. The track is always worth a good deal as old material, and the ballast can always be utilized when the line is converted into a standard gauge light railway.

(¹) Owing to their short life, old motor buses have practically no selling value.

Table II.

—	*70,000 train-kilometres (43,500 train-miles).*		*140,000 train-kilometres (87,000 train miles).*		*210,000 train-kilometres (130,500 train-miles).*	
	Cost per kilometre, in pfennigs (in pence per mile).	Total cost.	Cost per kilometre, in pfennigs (in pence per mile).	Total cost.	Cost per kilometre, in pfennigs (in pence per mile).	Total cost.
A. — Capital expenditure.						
		Marks. (£)		Marks. (£)		Marks. (£)
13 kilometres (8·1 miles) of Vignoles track of 10 kilograms (20·16 lb. per yard), on iron sleepers, at 8·5 marks per metre (7*s.* 9·27*d.* per yard)	...	110,500 (5,525)	...	110,500 (5,525)	...	110,500 (5,525)
Laying the track, including ballasting, remaking macadamized or other surface, at 6 marks per metre (5*s.* 5·84*d.* per yard)	...	78,000 (3,900)	...	78,000 (3,900)	...	78,000 (3,900)
2 motor cars (1 as reserve), 3 cars (1 as reserve) and 4 cars (1 as reserve), at 3,500 marcs (£ 175).	...	7,000 (350)	...	10,500 (525)	...	14,000 (700)
2, 3 and 4 cars at 600 marcs (£30)	...	1,200 (60)	...	1,800 (90)	...	2,400 (120)
Depot, offices and workshops, land included . .	...	13,000 (650)	...	15,000 (750)	...	17,000 (850)
Tools in workshops	...	5,000 (250)	...	5,000 (250)	...	6,000 (300)
Sundries and necessary cash in hand	...	5,300 (265)	...	6,200 (310)	...	7,100 (355)
Total. . .	...	220,000 (11,000)	...	227,000 (11,350)	...	235,000 (11,750)
B. — Working expenses.						
a) *Motor cars and track.*						
		Marks. (£ s.)		Marks. (£		Marks. (£ s.)
Cost of management, including stationery and law expenses	4·29 (0·83)	3,000 (150 0)	2·71 (0·52)	3,800 (190)	1·90 (0·37)	4,000 (200 0)
Pay of 3, 4 and 6 drivers, at 1,200 marks (£60) each, all included	5·14 (0·99)	3,600 (180 0)	3·43 (0·66)	4,800 (240)	3·43 (0·66)	7,200 (360 0)
Petrol, 85 grams per car-kilometre (77·20 drams per car-mile), at 29 pfennigs per kilogram (1·58*d.* per lb.)	2·50 (0·48)	1,750 (87 10)	2·50 (0·48)	3,500 (175)	2·50 (0·48)	5,250 (262 10)
Maintenance of cars, including lubrication and lighting	3·50 (0·68)	2,450 (122 10)	3·50 (0·68)	4,900 (245)	3·50 (0·68)	7,350 (367 10)
Maintenance and lighting of track, at 200, 220 and 250 marks per kilometre (£16.2*s.*, £17.14*s.* and £20.2*s.* per mile)	3·43 (0·66)	2,400 (120 0)	1·89 (0·36)	2,640 (132)	1·43 (0·28)	3,000 (150 0)
Fire and accident insurance	0·57 (0·11)	400 (20 0)	0·43 (0·08)	600 (30)	0·33 (0·06)	700 (35 0)
Total. . .	19·43 (3·75)	13,600 (680 0)	14·46 (2·78)	20,240 (1,012)	13·09 (2·53)	27,500 (1,375 0)
b) *Trailers.*						
		Marks. (£ s.)		Marks. (£ s.)		Marks. (£ s.)
Petrol at 70 grams per kilometre (63·58 drams per mile)	2·03 (0·39)	305 (15 5)	2·03 (0·39)	467 (23 7)	2·03 (0·39)	609 (30 9)
Maintenance of trailers	0·80 (0·15)	120 (6 0)	0·80 (0·15)	184 (9 4)	0·80 (0·15)	240 (12 0)
Total. . .	2·83 (0·54)	425 (21 5)	2·83 (0·54)	651 (32 11)	2·83 (0·54)	849 (42 9)
Total working expenses, goods service included.	22·26 (4·29)	14,025 (701 5)	17·29 (3·32)	20,891 (1,044 11)	15·92 (3·07)	28,349 (1,417 9)
C. — Interest and sinking fund.						
		Marks. (£)		Marks. (£ s.)		Marks. (£ s.)

…very, of the value of the rails	…	6,500 (325 0)	…	7,367 (368 7)	…	8,500 (425 0)
Depreciation of cars, at 1/9 their value	…	778 (38 18)	…	1,167 (58 7)	…	1,555 (77 15)
— of the tools, 16 per cent.	…	800 (40 0)	…	800 (40 0)	…	960 (48 0)
— of the buildings, 2 per cent.	…	200 (10 0)	…	240 (12 0)	…	280 (14 0)
Total, heading *C*.	22·83 (4·41)	15,978 (798 18)	12·51 (2·42)	17,519 (875 19)	9·29 (1·79)	19,520 (976 0)
Working expenses	19·43 (3·75)	13,600 (680 0)	14·46 (2·78)	20,240 (1,012 0)	13·09 (2·53)	27,500 (1,375 0)
Cost of a service for passengers only.						
Total cost of motor car	42·26 (8·16)	29,578 (1,478 18)	26·97 (5·20)	37,759 (1,887 19)	22·38 (4·32)	47,020 (2,351 0)
Cost per passenger-kilometre (per passenger-mile) if seven seats are occupied	6·0 (1·16)	…	3·9 (0·75)	…	3·2 (0·62)	…
As against this, the similar cost in the case of a bus service is	58·39 (11·28)	40,875 (2,043 15)	54·85 (10·59)	76,790 (3,839 10)	53·78 (10·39)	112,945 (5,647 5)
And per passenger-kilometre (per passenger-mile), if seven seats are occupied on the average	8·3 (1·60)	…	7·8 (1·51)	…	7·7 (1·49)	…
Cost of a service for passengers, mails and luggage.						
Conditions assumed.						
Carriage of mails, per year.	…	2,500 (125 0)	…	3,500 (175 0)	…	4,000 (200 0)
Or per car-kilometre (per car-mile)	3·57 (0·69)	…	2·50 (0·48)	…	1·90 (0·37)	…
Carriage of luggage, at 60 pfennigs (7·2*d.*) per trip.	5·00 (0·97)	3,500 (175 0)	5·00 (0·97)	7,000 (350 0)	5·00 (0·97)	14,000 (700 0)
The passenger service is therefore relieved to the extent of	8·57 (1·66)	6,000 (300 0)	7·50 (1·45)	10,500 (525 0)	6·90 (1·34)	18,000 (900 0)
Therefore the passenger traffic has to earn :						
Railway :						
Per car-kilometre (per car-mile)	33·69 (6·51)	23,578 (1,178 18)	19·47 (3·76)	27,259 (1,362 19)	15·48 (2·99)	29,020 (1,451 0)
Per passenger-kilometre (per passenger-mile), if seven seats are occupied on the average.	4·8 (0·93)	…	2·8 (0·54)	…	2·2 (0·42)	…
Motor bus :						
Per car-kilometre (per car-mile)	49·82 (9·62)	34,875 (1,743 15)	47·35 (9·14)	66,290 (3,314 10)	46·88 (9·05)	94,945 (4,747 5)
Per passenger-kilometre (per passenger-mile), if seven seats are occupied on the average.	7·1 (1·37)	…	6·8 (1·31)	…	6·7 (1·29)	…
Cost of a service for passengers, mails, luggage and goods.						
Conditions assumed.						
Receipts of motor car, 18 pfennigs (2·16*d.*) per trip, or per year.	…	1,050 (52 10)	…	2,100 (105 0)	…	3,150 (157 10)
Receipts of goods van, average load 1 ton, at 16 pfennigs per ton-kilometre (3·14*d.* per English ton-mile) = 1·92 mark (1*s.* 11·04*d.*) per trip, or per year	…	2,400 (120 0)	…	3,680 (184 0)	…	4,800 (240 0)
Total receipts, goods traffic.	…	3,450 (172 10)	…	5,780 (289 0)	…	7,950 (397 10)
Less cost of trailers	…	120 (6 0)	…	184 (9 4)	…	240 (12 0)
Net receipts, goods traffic	4·76 (0·92)	3,330 (166 10)	4·00 (0·77)	5,596 (279 16)	3·67 (0·71)	7,710 (385 10)
Therefore the passenger service has to earn :						
Railway.	28·93 (5·59)	20,248 (1,012 8)	15·47 (2·99)	21,663 (1,083 3)	10·15 (1·96)	21,310 (1,065 10)
Per passenger-kilometre (per passenger-mile), if seven seats are occupied on the average.	4·1 (0·79)	…	2·2 (0·42)	…	1·5 (0·29)	…
Motor bus service, not carrying goods, as above.	7·1 (1·37)	34,875 (1,743 15)	6·8 (1·31)	66,290 (3,314 10)	6·7 (1·29)	94,945 (4,747 5)

(1) Owing to expectations of future development, money for a railway can be raised at 2·5 per cent.

However that may be, we have tried, by calculating the expenses and taking as our basis what we know is possible in the way of receipts per car-kilometre, to prove that the capital outlay of a rural motor bus service is lost in every case (¹), whereas a railway of even the most modest character has at least a chance of survival, owing to its reduced rates and the improvement of the district concerned.

Naturally this is however not so, if for some reason or other tramways are not allowed. Such an El Dorado for motor buses is to be found in London. Permission cannot be got to build a tramway in the City itself. Thus the motor bus serves as a make-shift and the explanation of the exceptional favour it is in at present, is that the traffic conditions had become intolerable.

Moreover, the choice between railway and motor bus can be affected in special cases by a quality hitherto not mentioned, namely that a motor bus can travel pretty well when there is snow. The report of the Bavarian Minister of Ways and Communications states as follows :

« The difficulties due to snow were limited to the actual time of snowfall, consequently to but few days. Two series of phenomena were observed. As long as it was possible for the car wheels to obtain necessary adhesion, either by contact with the ground through the layer of snow (this, owing to the great weight of the cars, still happened when there were about 25 centimetres [10 inches] of fresh snow), or by contact with the rough surfaces of the ruts made in the snow by other vehicles, only the first car running during a snowfall was delayed a little. Once that had gone through, the service could be continued without difficulty.

« If on the other hand, fresh snow fell on to a deep layer of old snow coated with ice by the action of sun and frost, the wheels began to slip at places where the new snow had not united with the old and where there was not enough friction between the tires and the previously made ruts; the buses then remained stuck until the necessary adhesion for propulsion was obtained by putting down sand. This difficulty will be overcome in the future as follows: when new snow falls on an ice-coated surface, a motor van (sanding van) will be sent ahead in good time before the buses have to run. This motor van will be equipped with large sanding apparatus, delivering sand in front of the back wheels; the van will thus make a track for itself and for the buses it precedes.

« The layer of snow itself has not been found an obstacle to the running. On dry snow, on frozen snow and on thawing snow, the cars ran without any delay worth mentioning; the adhesion of the rubber tires sufficed. The depth of snow (maximum depth last winter 1·2 metres [4 feet]) had no bad effect. »

Under such conditions, a railway could either not run or only at an excessive cost, and if such conditions lasted for any length of time, this would not be justified by the small amount of traffic. The motor bus is then in its right place; but here again there is no question of profit, as the country folk cannot afford to pay high fares, and the tourist who might do so will certainly stay at home when snow is on.

In order to show that we have in no way exaggerated the financial want of success to be expected in the case of a rural motor bus service under existing conditions, we will

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(¹) Tourist traffic in certain favourable cases may give rise to an exception.

quote the following extracts from the reports of the two lines, mentioned above, of Dettmannsdorf and Sonthofen :

« The Dettmannsdorf-Marlow line connects Marlow, which has 1,800 inhabitants, with Dettmannsdorf railway station. The facilities now offered to the public are evidently superior as regards fares, convenience, punctuality, time required for the journey, and frequency of service, to what they were when there was a private service, with ordinary vehicles. The motor buses are much used, and the passenger traffic has grown : the undertaking has satisfactorily fulfilled the double object of improving communications and stimulating the traffic. On the other hand, the financial results are indifferent. The expenses and receipts for 22,771 car-kilometres (14,149 car-miles) are given below in table III.

Table III.

—	Total.				Per car-kilometre (per car-mile).	
	Marks.	(£	s.	d.)	Pfennigs.	(Deniers.)
WORKING EXPENSES.						
Drivers (pay, allowances, uniforms, etc.)	2,868·13	(143	8	1·6)	12·6	(2·43)
Maintenance of cars.	2,474·91	(123	14	10·9)	10·9	(2·10)
Renewal of rubber tires	3,793·05	(189	13	0·6)	16·7	(3·23)
Petrol, carriage included	2,890·27	(144	10	3·2)	12·7	(2·45)
Lighting and lubrication, glycerine, maintenance of appliances	945·38	(47	5	4·6)	4·1	(0·79)
Telephone subscription, stationery	464·74	(23	4	8·9)	2·1	(0·41)
Total . . .	13,436·48	(671	16	5·8)	59·1	(11·41)
RECEIPTS.						
Passengers	5,266·50	(263	6	6·0)	23·1	(4·46)
Luggage and parcels	313·70	(15	13	8·4)	1·4	(0 27)
Mail	2,000·00	(100	0	0·0)	8·8	(1·70)
Miscellaneous	6·83	(0	6	10·0)	...	
Total . . .	7,587·03	(379	7	0·4)	33·3	(6·43)
Deficit. . .	5,849·45	(292	9	5·4)	25 8	(4·98)

« In this table the preliminary expenditure on organization of the service, amounting to 2,404·18 marks (£120.4*s.* 2·2*d.*) is not allowed for.

« The expenses have to be increased by the interest on the cost of the two cars, say 3·5 per cent on 40,000 marks (£2,000) = 1,400 marks (£70), and by the depreciation of the cars. The life of a motor bus has sometimes been estimated, by car-builders, at ten years. In the present case, the results obtained up till now show that 5,100 marks

(£255) must be allowed per year, or 22·4 pfennigs per kilometre (4·33*d.* per mile) (1), so that the total expenditure becomes 19,936 marks (£996.16*s.*), or 87 pfennigs per kilometre (1*s.* 4·80*d.* per mile). The deficit is thus 12,943 marks (£647.3*s.*), or 54 pfennigs per kilometre (10·43*d.* per mile).

« More favourable results in future years are not to be expected; on the one hand, the cost of maintenance, which is already considerable, will increase rather than decrease as the cars become older; on the other hand, the local conditions are such that any important growth in the traffic is hardly probable.

« 3,073 second class and 14,259 third class passengers were carried on 3,740 journeys. Consequently, the mean utilization of each seat on each trip was 0·82 in the second class and 3·81 in the third. As each car has 5 second class and 8 third class seats, the utilization of the seats was 16·5 per cent in the second class and 47·6 in the third. If the cars had always been full on every trip, the passenger fares would have amounted to :

5 × 0·40 + 8 × 0·30 = 4.40 marcs (4*s.* 4·8*d.*), or a total of 3,740 × 4·40 . . . . =	16,456·00	marks	(£822.16*s.* 0*d.*).
Plus receipts for mail and luggage, say	2,313·70	—	(£115.13*s.* 8·4*d.*).
Total. . .	18,769·70	marks	(£938. 9*s.* 8·4*d.*).
Consequently, the total expenditure being.	19,936·48	—	(£996.16*s.* 5·8*d.*).
the deficit would still have amounted to . . . . with the cars always full up.	1,166·78	—	(£58. 6*s.* 9·4*d.*).

« The regular service could always be carried on, in spite of occasional damage, because there is never more than one car running, the other acting as reserve. »

On the Sonthofen-Hindelang line, after deduction of the extra initial expenditure, there is left a total of 11,800 marks (£590) of expenses for 19,744 bus-kilometres (12,269 bus-miles) and 3,897 van-kilometres (2,422 van-miles), say 50 pfennigs per kilometre (9·66*d.* per mile), including interest at 4 per cent on the cars. The depreciation of the cars accounts for 10 pfennigs per kilometre (1·93*d.* per mile), the maintenance for 7 pfennigs per kilometre (1·35*d.* per mile), and the renewal of the rubber tires is only taken at 12 marks (12*s.*) altogether. Thus at that period, no tire had yet been renewed. If we add for this item 15 pfennigs per kilometre (2·90*d.* per mile) (the life of a tire being taken as 18,000 kilometres [11,180 miles]), and also 5 pfennigs per kilometre (0·97*d.* per mile) more for repairs (this item has clearly been lower than usual), and 5 pfennigs per kilometre (0·97*d.* per mile) for the proper maintenance of the cars (2) we obtain 75 pfennigs per kilometre (1*s.* 2·48*d.* per mile), or, for 23,641 car-kilometres (14,690 car-miles), a total af 17,731 marks (£886.11*s.*). The passenger receipts (3), at 5 pfennigs per kilometre (0·97*d.* per mile), plus 33 marks (£1.13*s.*) for luggage, amounted to 9,996 marks (£499.16*s.*), or 50·6 pfennigs per kilometre (9·77*d.* per mile). It is possible that this sum will be increased by 2,300 marks (£115) for the carriage of mails, which will increase the receipts of the passenger cars to 12,296 marks (£614.16*s.*), or 62·3 pfennigs per kilometre (1*s.* 0·03*d.* per mile). The receipts of the whole undertaking, including 917 marks (£45.17*s.*) of goods receipts, will then be 13,213 marks (£660.13*s.*) for 23,641 car-kilometres (14,690 car-miles), or 55·9 pfennigs per kilometre (10·80*d.* per mile). If the expenditure is 75 pfennigs per kilometre (1*s.* 2·48*d.* per mile) the deficit will thus be 4,518 marks (£225.18*s.*), or about 19 pfennigs per kilometre (3·67*d.* per mile).

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(1) *See* particulars on pages 503 and 504.

(2) Badly kept roads.

(3) For the 19,744 bus-kilometres (12,269 bus-miles).

The official statement, in discussing the results, that : « The examination of the financial results hitherto obtained and the factors affecting them make it possible to hope that it will be possible to obtain satisfactory financial results on future lines while keeping to the fares (5 pfennigs per passenger per kilometre [0·97*d.* per passenger per mile]) adopted on the experimental lines » merely shows that tire renewal has been neglected and too low a figure for maintenance adopted.

Of the existing rural lines, only the Partenkirchen - Kochel line, 52 kilometres (32·3 miles) long, with tourist traffic, has returned a profit : the receipts are 3·38 marks (3*s.* 4·56*d.*) per passenger, 15·62 pfennigs per passenger-kilometre (3·02*d.* per passenger-mile) and 1·04 marks per car-kilometre (1*s.* 8·08*d.* per car-mile), as against total expenses of 90·64 pfennigs per car-kilometre (1*s.* 5·50*d.* per car-mile), justifying, in the opinion of the operators, a dividend of 4 per cent. The conditions are exceptional in this case, which cannot be used for purposes of general comparison.

Now although, such being the present state of affairs, motor bus prospects are not particularly bright, it would be wrong to conclude that this new vehicle will disappear. That is not probable, especially as far as large cities are concerned. It is quite possible that if the import duty now charged on petrol is abolished, if a cheap substitute for rubber is invented and if the machinery is simplified, the working expenses will become sufficiently reduced to enable the motor bus to give good financial results in a wider field ; it being always assumed that the motor bus will not be called upon to contribute to the upkeep of the roads.

But on the other hand, the question is closely connected with that of the up-keep of the public roads. Mr. Burford, the Milnes-Daimler representative, has plainly stated that the introduction of a larger number of motor bus services depends solely on the improvement of the roads and road surfaces.

Now if this is so, if the roads have to be especially improved for the motor buses, the question of making them contribute will certainly be raised. It is true that in such a case, the motor bus in its present shape will no longer have any chance of coming into general use. The present situation is certainly a very curious one : we mean the different treatment meted out to tramways and motor buses. The tramways contribute largely to the maintenance of the paving, which they do not use ; the motor buses use the paving, contribute nothing, and want to have it improved. In order to judge what this comes to, it is only necessary to remember that tramways actually pay up to over 20 per cent of their gross receipts or up to 8 pfennigs per car-kilometre (1·54*d.* per car-mile) for rent and maintenance of the streets.

There are at present but few reports on the wear of roads and road surfaces. Mr. Bade, railway secretary, makes the following statement about the Dettmannsdorf line, which runs on a macadam road :

« The road on which the motor cars run, has become worn very considerably. Six to seven weeks after the service started, there were already an astonishing number of little holes in the macadam, having quite a different appearance from the wear produced by horse traffic. These holes are evidently produced by the sucking and blowing action of the rubber tires and by the heavy wheel-loads. At the end of a few months, there were two well-marked ruts, made by the motor cars; and drivers consequently received instructions to vary their track. It therefore seems nearly certain that the cost of maintaining the road will be increased materially, and if the motor service is to become permanent, it may become necessary to consider whether it would not be economically better to rebuild the road and make it more substantial. A smooth and uniform surface, such as concrete for instance, would evidently also reduce the wear and tear of the motor cars, particularly of the rubber tires. »

Some local authorities who have tried motor buses, hesitate to authorize the establishment of new services, because the wear of the roads is very appreciable.

It seems to the author that assuming that the motor bus remains exempt from any such taxation, it is more particularly in the form of the steam bus that its use will become extended in the near future. The steam motor is free from the most serious defect of the petrol motor car, namely the changing from one speed to another; like the electric motor, the steam motor is able to proportion the power it produces to that required at any moment and it runs silently. The only weak point was formerly the boiler, and that has been much improved. It is a very remarkable fact that Mr. Darracq, the well-known manufacturer of petrol motor cars, has publicly admitted that after a careful study of the petrol motor bus, his firm decided to give up this type and to undertake the construction of steam motor buses; that in France, the cradle and home of automobilism, the introduction of the motor bus hardly makes any progress; and that in Belgium, that enterprising and business-like country, up to the summer of 1906 there was, as far as the author knows, no motor bus in use. The trouble arising from the fact that it is difficult to adapt the petrol motor to suit different services must really be very great, as in order to overcome them, there is a return, in England, to the complicated combination of the dynamo and petrol motor known as the "automixed" system, which it is at present being tried.

With the help of the data given, any engineer familiar with transport systems can calculate, in any given case, the life of a competitive service of motor buses, given its financial resources and its receipts per car-kilometre. Under the present conditions, if, which rarely happens, the working expenses proper are earned, the competition will only in exceptional cases last longer than the first period of renewal, which, as an extreme limit, will come when each bus has run 200,000 kilometres (124,000 miles).

[656 .259]

NEW APPARATUS FOR CONTROLLING THE SPEED OF TRAINS,

By H. P. MAAS-GEESTERANUS,

ENGINEER,
HEAD OF DIVISION, DUTCH RAILWAY COMPANY.

Figs. 1 to 4, pp. 523 and 524.

(*Zeitung des Vereins.*)

Running at too high a speed over sections on which reduced speed is definitely prescribed, is no doubt one of the most common infractions of railway regulations. It occurs less frequently on sections where reduced speed is only temporarily prescribed, on account of renewals or other similar causes, than on those where reduced speed is always prescribed, on account of sharp curves, steep gradients or constructive works. On a large iron bridge, for instance, a train running at full speed involves no immediate danger; nevertheless, in order to keep the bridge in good condition it is necessary to fix a speed limit and to take measures to insure that the regulation is observed and to discover if it is broken, so that any offender may be punished. For this purpose, speed gauges are used.

As the speed is a function of time and distance, it is necessary to measure either the time taken in running a given distance, or the distance run in a given time.

The devices ordinarily used to measure the speed of trains passing a given point, are based on measuring the time taken by a train in running over a given fixed distance. By means of a clockwork movement, this time is recorded as a line which can be measured with a graduated rule. In order that the time measured may not be too short, the distance chosen is generally of considerable length, generally 500 metres (0·31 mile), sometimes even 1,000 metres (0·62 mile).

But what we determine in this way is only a mean speed, and it may frequently be observed that a driver when entering such a reduced speed section is running at a very high speed, and then applies the brakes rather forcibly. The result is that by the time he leaves the section, he is running so slowly that the mean velocity does not exceed the prescribed limit.

Now such braking is very bad for metal bridges, and on sharp curves, it is more dangerous than running at high speed.

In principle it is, therefore, better to measure the speed at the moment of entering the section concerned, than to determine the mean speed over the whole section. The actual speed at any moment can hardly be measured except on the locomotive itself; on the track it will no doubt always be necessary to take a distance as our basis. But the shorter the distance, the nearer we get to the true speed. Up to the present no suitable device for short distances was available; the apparatus here described will probably meet this want.

In the first place, such device must be able to record a sufficiently short time-interval, so as to serve as our basis in observing the passage of the train.

The oscillation of a pendulum of known length can, for instance, be used to determine a short time interval with sufficient accuracy. If such a pendulum, driven electrically or by a spring, has a combined electric release and check, so arranged that each time the pendulum is released it can only make one complete vibration (to and fro), the time the pendulum takes in executing this complete vibration is a definite unit of time. We will now describe, with the help of the figures reproduced, the apparatus in which this principle is applied.

The pendulum has at its lower end a small steel blade *a* (fig. 1), by which it hooks obliquely behind a catch *c* on the armature *d* of the releasing electro-magnet.

When the armature *d* is attracted by the electro-magnet, the pendulum begins to swing, and after executing a complete vibration returns into its initial position; it can only do so if supplied during its movement with a certain amount of energy. This is supplied by an automatic contact and a second electro (fig. 2), the arrangement being similar to that used in electric clocks. If the armature *d* is still attracted when the pendulum has executed its complete vibration, the latter is held by the two hooks *b*; when the armature rises, the pendulum is once more in its initial position behind *c*. If the armature has already risen before the pendulum has completed its swing, the pendulum presses down the spring catch *c*, passes over it, and then catches behind it.

The pendulum has a cross piece fixed to it near the middle; this on the one side opens contact *i* when the pendulum is in the position of rest (fig. 2), and on the other side supplies the pendulum with the necessary energy by means of contact *g*.

The speed is controlled in the following way: When passing R, the train closes a circuit which sets the pendulum in movement. But as soon as the pendulum begins to swing, the contact *i*, which is on the same circuit as a second contact S on the track, is closed. If the train reaches this second contact before the pendulum has completed its oscillation, this circuit is closed and operates a bell or an electric recorder of the usual type. Now the distance between R and S must be such that the bell rings or the recorder records when the speed limit specified is exceeded.

Figures 2 and 3 show, diagrammatically, the flow of the current. It is to be noted that a relay is provided in case the apparatus is to be used on a single-track line and be operated by trains in the one direction only (fig. 3).

When a train running in the direction $x - y$ reaches the contact R, it completes the circuit through E, R, *p*, *n*, the electro-magnet *e* and the battery B_2, and back to E. The armature of the electro-magnet *e* is attracted, *c* releases the pendulum which swings to the right, and after its return is again held by the armature *d*, as described above. When the train reaches the contact S, the circuit of battery B_1 is closed, the armature *q* of relay *l* is attracted, and if, the pendulum not yet having returned to its position of rest, the contact *i* remains closed, a new circuit is formed: battery B_2, M, *m*, *o*, *i*, B_2. Consequently the recorder, which continues its movement and has its paper graduated in units of time, shows what trains exceeded the speed limits specified.

A train running in the opposite direction first reaches the contact S. At this moment, the relay *l* attracts its armature *q*, the circuit of contact R is interrupted between *n* and *p* and the electro-magnet *e* is not excited when the train passes R; consequently, the pendulum is not released.

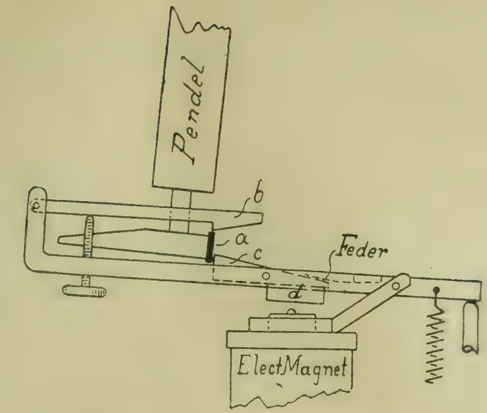

Fig. 1. — Pendulum at rest.

Explanation of German terms : Elect Magnet = Electromagnet. — Feder = Spring. — Pendel = Pendulum.

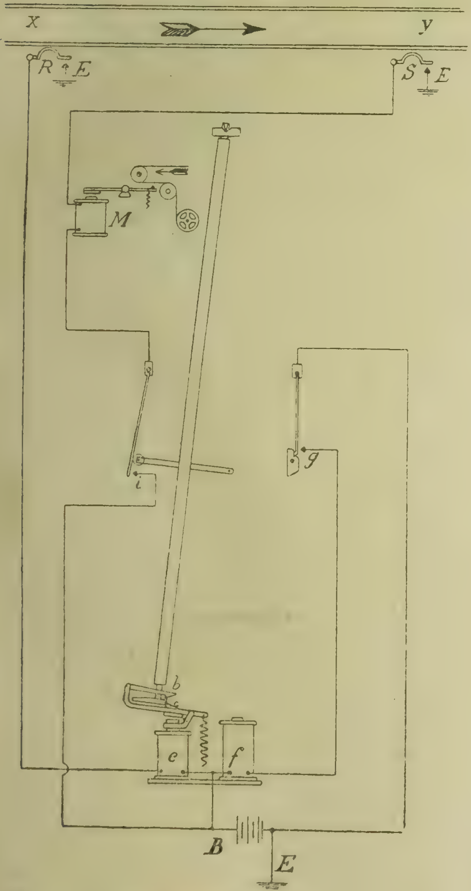

Fig. 2. — Arrangement on track where trains run in only direction only.

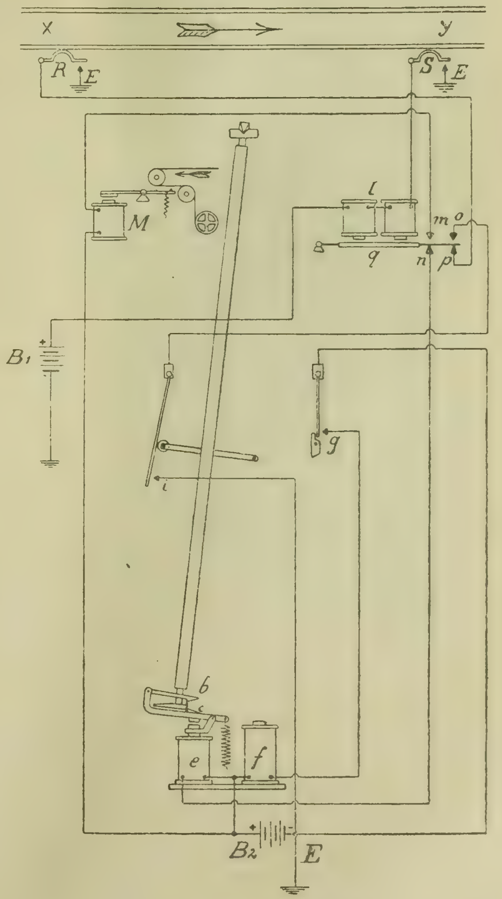

Fig. 3. — Arrangement on tracks where trains run in either direction, but reduced speed is only prescribed in one direction.

It is to be noted that the contact S is correctly a time contact; otherwise the last vehicle of a train running in the direction $y - x$ would by means of contact R release the pendulum. It is true that this does not matter as far as the records are concerned, as the recorder cannot start once contact S is open; but it is better not to release the pendulum except when required.

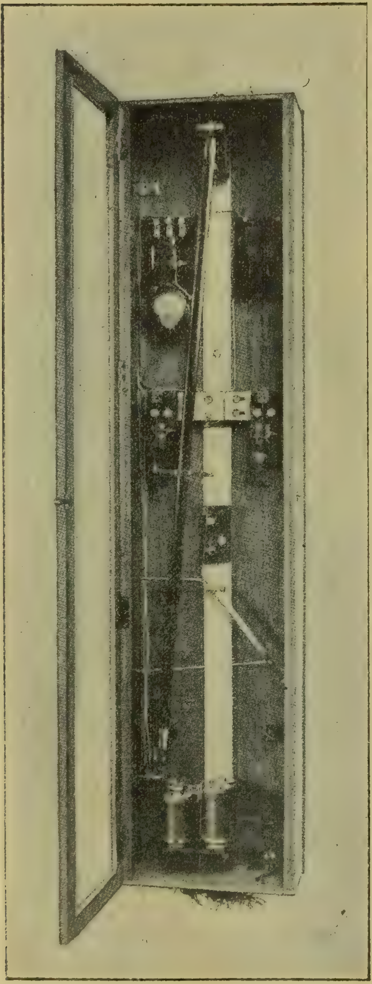
Fig. 4. — General view.

A suitable form for contact R is an insulated rail, as the contact must remain closed while the train passes; any interruption might enable the pendulum to swing a second time and erroneous records might result.

If the apparatus is to be used on a single-track line for trains running in both directions, two contacts R are provided, for releasing the pendulum, one for each direction; the contact S, on the other hand, is used for both directions.

As stated above, the distance between contacts R and S must be adjusted so as to suit the speed limit concerned; but the inertia of the armature and of the pendulum must be allowed for.

In the apparatus hitherto constructed, the pendulum used is very nearly a seconds pendulum. With a speed limit of 30 kilometres (18·6 miles) per hour, the contacts should therefore be 16·66 metres (54 ft. 8 in.) apart. But it was found in practice that owing to the inertia of the moving parts, the distance had to be greater. The effect of the inertia was determined with accuracy in the following manner :

The contact S was short-circuited, and instead of it a piece of thin copper wire was inserted in the circuit of the recorder; this wire was stretched over the rail a little behind contact R. The recorder circuit was thus only interrupted at contact *i* and the recorder acted as soon as the pendulum moved, that is to say, as soon as contact *i* was closed. Then a locomotive was run over the section at a definite speed. This locomotive set the pendulum swinging; but the first wheel, very soon after leaving the contact R, broke the fine wire inserted in the recorder circuit. If this took place before the pendulum moved and the contact *i* was closed, the recorder did not act.

By repeated alterations in the position of the wire, the inertia error was accurately determined, and it was found to amount to 0·2 second.

In order to determine the period of the pendulum, the hooks *b* are lifted, and the armature attracted. The pendulum then goes on swinging, and the number of oscillations made in one minute is counted. 0·2 is then added to the period, and the result is taken as basis in calculating the distance between the contacts. The resulting accuracy is greater than what is required. It may, moreover, be remarked that an appliance of this character need not be an instrument of precision.

When a speed limit of 30 kilometres (18·6 miles) per hour is prescribed, there is no question of any penalty if a driver is running at 30·5 kilometres (19 miles) per hour. The limit of 30 kilometres (18·6 miles) per hour is anyhow a more or less arbitrary one, and thus it is advisable to take the next highest round number for the figure determined for the distance between the contacts.

It would be very easy to calibrate the apparatus very accurately; it would, for instance, only be necessary to fix contacts to a fly-wheel revolving at a determined speed. But at present no such exact calibration has appeared necessary.

We may add that if a conducting wire were to break or a battery to fail, no record would be made; it is hardly possible for the apparatus to produce any incorrect record which would result in an unjust punishment of the driver.

The apparatus is contained in a case 31 centimetres (1 ft. $^3/_{16}$ in.) wide and 1·40 metres (4 ft. 7 in.) in height (fig. 4), which can be conveniently hung on a hook. It is carefully adjusted, like a pendulum clock, by two screws. The case has a glass front; the station-master or signalman in charge can thus see if the pendulum is working satisfactorily. It is advisable to notice at intervals whether the recorder is working properly.

The figure shows an apparatus in which the recorder is replaced by an ordinary continuous-action bell. When a train has exceeded the specified speed limit, the bell goes on ringing till the employee in charge stops it by pulling a string; then he notes down the train concerned. This system is simpler than having a recorder, but then there is an absence of proof.

A lever is also shown in the figure, which makes it possible to bring back the pendulum into its position of rest without opening the case. This lever is only present in the older patterns, and is now no longer put in.

The apparatus described has been in use for some time in Holland; it is now patented in Germany. It will probably also be used in that country, for it is a real improvement on the appliances now in use, as it records the actual speed, not the mean speed, of the trains concerned.

BEARING ALLOYS (1),

By Alfred SUGGATE,

ASSOCIATE MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS.

Figs. 1 and 2, pp. 529 and 533.

(*The Engineer.*)

There is a voluminous amount of literature on alloys from the chemist, experimentalist, and scientist's point of view, but, comparatively speaking, none at all from the practical engineer's standpoint. True, he can consult tables giving the proportion by weight of every known alloy, and after making a selection for his particular case, the chances are that the chosen alloy will fail to give satisfaction. In this paper, the author will endeavour to describe some of the leading conditions that must be complied with to make the selected alloy a success, and although the matter here treated of is principally with reference to white metal, it will be well to classify the leading alloys at the beginning of this article :

1° Copper and tin, bronze ; trade name, gun-metal ;

2° Copper and zinc, brass ; trade name, brass ;

3° Copper, tin, and zinc ; trade name, Babbitt mixtures ;

4° Aluminium, phosphor, and manganese, brasses and bronzes ; also Sterro and Delta metal, known in the trade by their respective names ;

5° Copper and tin, with antimony or lead ; trade name, white metal, or anti-friction alloys. The softer mixtures used as lining metals ;

6° Anti-friction alloys ; trade name, lining metals.

In the selection of an alloy for a particular purpose, it often happens that considerations other than its adaptability determines the selection ; as, for instance, a railway may be in close proximity to mines and smelting furnaces, and the easy obtaining of their products might determine the selection of an inferior lining alloy for the carriage axles, to the exclusion of a more suitable but dearer mixture.

It may be taken for granted that if a journal of good proportions running in bronze bearings well lubricated, with its alignment maintained under working stress, gets hot, and abrasion of the bearings follows, no white metal lining substitute, whatever its composition, will prove satisfactory, because the unit pressure on the bearing is too much for the velocity of the journal. On the other and, suppose the heating and abrasion to be the result of the bearing not maintaining its alignment under stress, then it is possible that a lining of white metal will answer, because it may yield to the intensity of the journal pressure, on account of its plasticity, and thus distribute that pressure over a larger bearing surface, thereby reducing its unit amount, with the result of cooler running. Quite recently the chief locomotive engineer of one of the leading English railways decided to try bronze bearings in the large end of the connecting-rods in place of the white-metal lining hitherto in use. It was with difficulty they ran the engine for half the day, and upon examination, the bronze bearings were found to be ground away to such an extent as to render them useless, and recourse again had to be made to the white-metal lining. Here we have the engine running over lines of opposite curvature, thus alternating the alignment to each side of the bearing, and there being no give or yield in the bronze, abrasion ensued, and when that had commenced, the metal rapidly wore away.

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(1) This paper was read to the Manchester Students, Institution of Civil Engineers, at the opening of session 1904-5, but has not been hitherto printed.

These considerations lead to the inquiry : What is the unit intensity allowable to ensure cool running and an average life for a bearing? And in endeavouring to answer this question some notice must be taken of the material of which the journal is made. In good average practice, it is usual to make the journal and bearing of different materials, also the bearing is of a softer nature than the material of which the journal is made, but if as hard, or even harder, its physical properties should be quite distinct from those of the journal, otherwise heating and seizing will instantly occur in the absence of efficient lubrication. For instance, wrought iron journals have worked satisfactorily for long periods in cast iron bearings made of No. 1 cast iron. Here we have in opposition the toughness of the wrought iron, as against its complete absence in the cast iron. This practice cannot be recommended, as in the event of deficient lubrication, heating will occur, with abrasion to follow. The using of cast iron for bearings in supporting journals, is confined to the commoner class of machinery, their use in the better class being limited to half top bearings for shafting having no upward or lifting stresses.

Cast iron upon cast iron is found to wear well, if, coupled with efficient lubrication, the velocity and unit pressure is kept very low, as in the case of motion blocks and slide bars of engines; but should the metallic surfaces get dry through failure of the lubricating arrangements, the friction may engender so much heat as to induce a kind of union between the two surfaces technically known as " seizing, " with the result of stopping the moving parts or breakage of same. But when one of the surfaces is of gun-metal, the want of lubrication has the effect of wearing away the softer metal with great rapidity, but no " seizing " action takes place, for it is most important that if any part is to suffer, it should be the bearing and not the shaft. So long as the surfaces are separated by a film of oil, there can be no metallic attrition, and they would last for an unlimited time, if it were not for the chemical corrosion of the surfaces. Now, most of the best lubricants corrode metals, especially when brought into rubbing contact under pressure, as in a bearing. The passage of the oil removes the oxide or soap directly it is formed, thereby exposing the bright metal to further action. The order of the metals most sensitive to this corrosive action are as follows :

Zinc is the metal most readily corroded;
Lead not so easily corroded as zinc;
Copper and iron to a less extent than lead,
Tin and antimony not corroded at all.

It will be convenient here to call attention to the correct position of the oil cups, and also the oil scores. The author has seen well-proportioned bearings for large diameter journals, with ample lubricating arrangements, heat to such an extent that the water played upon them from the fire hose fizzes off the bearing as it would from a red-hot plate, to the surprise of the foreman and puzzlement of the designer, the whole difficulty arising from the incorrect position of the oiling passage and scores. All oiling arrangements must discharge the oil on the off side, or that side of the bearing which is opposite to the resultant pressure of the journal upon the bearing, and the oil scores must be cut upon the same principle — for instance, in line shafting, with the driving straps leading downwards, it is correct to oil through the top bearing, but if the straps lead upwards, so that the resultant pressure is vertical and is of greater amount than the weight of the shaft, the oil should be admitted through the bottom bearing, or if, for convenience, it is admitted through the top half, then an ample oil channel must be cut circumferentially completely round the top and bottom half, making connection with smaller oil scores, cut lengthwise, of the bearing in the bottom half of the same.

However appropriate the selected alloy may be for a special purpose, it is likely to prove a failure on incorrectly proportioned journals, hence it is well to remember that the diameter of a journal should be determined by the stiffness required, while its length is proportional to the journal's velocity and unit-bearing pressure combined. Common experience shows that for journals running at high speeds a greater length is necessary than for the same running at low speeds. Journals running at 150 revolutions per minute, and with a comparative low unit-bearing pressure, often have their brasses one diameter long, while lightly-stressed shafts, as, for instance, fan shafts, running at 1,500 revolutions per minute, have bearings six to eight diameters long.

Professor Rankine gives a formula for allowable unit-bearing pressure at varying journal speeds. The curve A in the Chart No. 1 (fig. 1) is constructed by means of this formula, and its intersection with the vertical and horizontal lines enables the correct unit-bearing pressure to be known when the velocity of the journal is given. It is to be noted that this curve gives the average every-day practice when the resultant pressure never varies in direction and but little in amount. A somewhat higher unit pressure, indicated by curve B, is allowable in journals running under similar conditions, but subjected to considerable vibrations or shocks, which contributes materially in ensuring successful lubrication, as, for instance, the axles of railway rolling stock, while in the case of journals in which the resultant pressure alternates from side to side of the bearing every revolution, and at the same time varies in amount from nothing to a maximum, and then back again to nothing, every half of its revolution, as in the case of an engine crank and crosshead pin, the unit pressure for velocity is given by the curve D. All other journals would run under conditions that could be met by some curve intermediate between B and D, as shown at C, that indicates a journal running under a pressure, part of which alternates every revolution, while the remaining part is constant in one fixed direction. The journals between the cranks of a triple-expansion engine answers to this condition, for the pull and thrust on the cranks due to the connecting-rods supply the first, while the weight of the cranks and attachments supply the second condition. Higher unit intensity of pressure are found in high-speed engines, but this is met, as a rule, by forced lubrication, and it must be remembered that the total driving force of the piston, divided by the product of the length of the crank pin, into its diameter, do not give a correct result of the actual unit pressure for the influence of rapidly reciprocating parts, tend to reduce the unit-bearing pressure to much below the amount found by the above incomplete calculation.

The more or less freedom of the air from grit and dust is another consideration of importance in deciding upon the alloy to be used. If the machine is intended to work in a place where the air is charged with fine carbon, iron or silicate dust, the alloy must not be of too soft a nature, otherwise the grit that works its way into the journal will become embedded in the bearings or white metal linings, causing the latter to lap away the journal at a rapid rate, with an inappreciable wear of the bearings; but with harder alloys, these grit particles are worked out without any danger of becoming embedded. In a locomotive engine the white-metal linings of the glands, motion or guide blocks, and excentric straps, may with advantage be of a harder nature than the bearing metals of the axles and coupling-rods, etc., because the alignment in the former case is maintained fairly constant, and the harder alloy will prevent the scouring of the surfaces from the dust, which is inseparable from the engine at high speeds, while in the latter case the want

A = For pressure constant in one direction as in line shafting and flywheel end of crank shaft.
B = For pressure constant in one direction with journal subjected to shocks and vibrations as in axles of railway rolling stock.
C = For pressures part constant in one direction and part alternating as in bearings between cranks in vertical marine engine.
D = For pressures varying from 0 to a maximum and alternating opposite sides of the journal each revolution as in connecting rod bearings.

NOTE. — In no case is the unit pressure on bearing to exceed 1,200 lbs. per square inch.

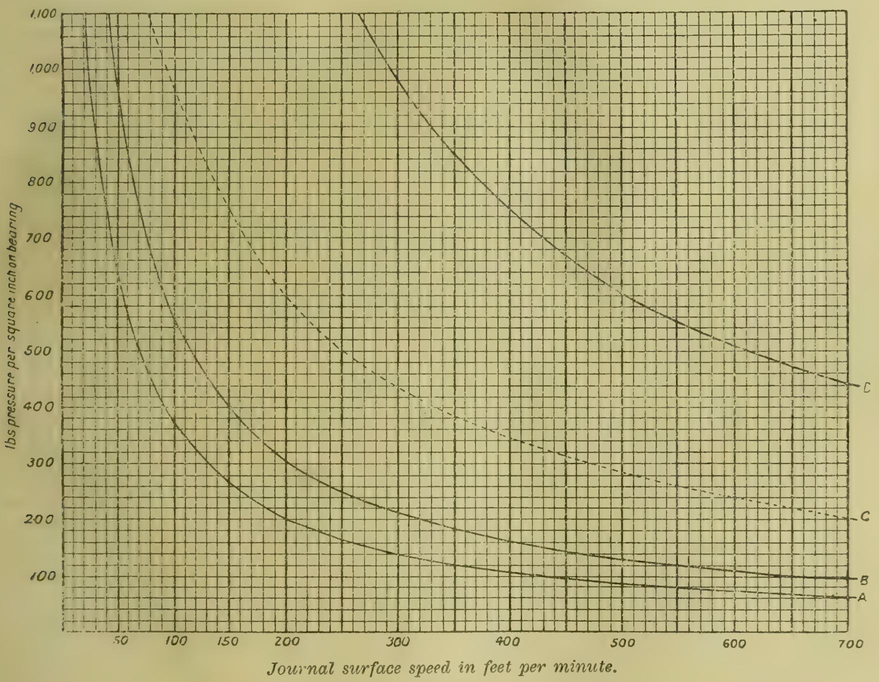

Fig. 1. — Chart No. 1. Connecting journal speed and bearing weight.

of alignment in the bearings compels a softer alloy to be adopted, and running the risk of wear of journal from any lapping action due to grit embedded in the bearings. Factory and marine engines working in well-ventilated rooms, where every care is taken to keep away the dust, may, if the unit pressure be kept low, have with advantage bearings of a softer nature than rolling mill engines running in open sheds, or coal-elevating and cutting machinery.

In the following table, the left-hand column gives the metals chiefly in use for bearing alloys, and the head lines at top of the remaining columns indicates the meaning of their respective numbers. As is usual in matters of which little is known, much diversity of opinion exists in the trade regarding the selection of the metals, and also their relative amount in percentage of the whole compound, to form the best alloy; yet, nevertheless, certain salient points are sufficiently prominent to guide us in our selection, both in kind and quantity, enabling us to produce the best alloy for the particular purpose in view, bearing in mind that the word " best, " as applied to an alloy, means that its composition is the best compromise to meet the many conditions under which it must support the journal, as it is an utter impossibility with our present knowledge to devise an alloy to reach the pinnacle of perfection in all requirements.

TABLE I.

METALS.	Atomic weights.	Atomic volumes $= \frac{\text{Atomic weights}}{\text{Specific gravity}}$	Combining values for tabular numbers.	Relative hardness, cast iron = 1,000.
Copper	63·5	7·65	9·0	301
Tin	118·0	15·92	0·6	27
Zinc	65 2	9·31	3·0	183
Lead	207·0	18·23	0·2	16
Antimony	120·0	17·88	14·0	...

It is of the first importance that the metals be the best of their respective kinds; if not, however careful our after manipulation may be, the resulting compound will prove disappointing. No consideration of saving money should tempt us to use up scrap, or junk, the composition of which, and its previous method of fusion and treatment, being unknown. Ten per cent of ill-conditioned junk will completely neutralise the good qualities of a compound, having its constituents selected from the purest metals. Some makers make use of the five metals named in the table in varying proportions, adding sometimes a small amount of iron, thus making six elements in the compound, while others claim equally good results from a compound consisting of only two metals. Now, considering that some experience and care is required to make a successful binary compound, how much more is required for an alloy having three or four constituents. There is a method of successfully doing it, by melting the different metals in groups of threes and twos, and casting into ingots, then re-melting and combining the ingots. But this requires skilled measuring and handling of the various metals, or else the more fusible ones will get unduly oxidised and wasted in amount, so as to be out of their proportion with the others; besides, the extra cost involved is altogether out of proportion with the additional advantage, if any, claimed for the resulting alloy. If four metals are selected for the alloy, the best method of procedure is to combine the three least fusible metals and cast into ingots, re-melting and adding the fourth more fusible metal prior to casting the bearing.

Charpy, in his admirable treatise on alloys, writes that the best antifriction metals are formed from ternary groups, and are preferable to more complicated mixtures of four or five metals, and with this conclusion the author fully agrees. Charpy cites the following as likely groups :

1st.	Copper.	Tin.	Antimony.
2nd	Lead.	Tin.	Antimony.
3rd	Copper.	Lead.	Antimony.
4th.	Zinc.	Tin.	Antimony.
5th.	Copper.	Tin.	Lead.

The lining metals most in favour with the large engineering firms for engine work are those with a small proportion of copper in their composition. Of these alloys, Babbitt's mixture, or some modification of it, undoubtedly heads the list; yet Babbitt's metal is a ternary compound. Some users prefer to purchase the genuine Babbitt, as it is termed, using it as bought for heavy work, and mixing with it a small quantity of lead for light work. This answers fairly well if the lead is added in correct proportion. "Magnolia" metal is largely advertised, and, from independent tests made by various engineers, apparently stands far ahead of the ordinary bearing alloys. Here, again, "Magnolia" from analysis is a ternary compound.

Lead added to an alloy tends to soften and render it plastic, lengthens the life of the bearing by diminishing its wear; in fact, it is the best wear-resisting metal known. At the same time, it slightly increases the friction of the journal. It will not readily combine with copper, except the mixture be brought up to a white heat, unless the copper has previously been melted with tin. The larger the amount of tin the more perfect the combination of the copper with the lead. This high temperature precludes the making of copper-lead alloy, except in factories equipped with a special furnace for melting same. The patent alloy known in the trade as plastic bronze, has some 1 per cent of nickel added to the copper to lower the temperature at which it solidifies, so that it may not squeeze out any part of free lead, or lead that may not have combined with the copper when the latter contracts in the act of solidifying.

Tin added to an alloy imparts to it rigidity and hardness, without increasing brittleness, and can produce alloys of sufficient compressive strength for nearly all purposes; at the same time, it tends to diminish the life of a bearing by increasing its rate of wear.

Antimony is a very poor wear-resisting metal, and is added to alloys mainly to harden them. Too much antimony in an alloy makes it brittle, and of a crystalline nature. The alloy known as antimonial lead is mainly used for lining the bearings of truck axles when a cheap and inferior metal is preferred.

Zinc, being less expensive than tin, frequently takes its place for alloying with copper, but the resulting compound is not as tough as when tin is used. It should never exceed 33 per cent by weight in the alloy with copper for bearings, otherwise they will be too brittle for use. Professor Goodman has shown that metals of low atomic volume, *i. e.*, $\frac{\text{atomic weight}}{\text{specific gravity}}$, increase friction, whilst those of high atomic volume decrease it, see the table. Also that the addition of bismuth up to 0·25 per cent by weight in alloys reduces friction — *vide* his paper, Institute of Mechanical Engineers.

In general, when mixing, always melt the metal having the highest fusion point first, then add the rest in the descending order of their respective melting points, reserving the more easily melted metal as the last to be added. Keep the surface of the molten metal covered with powdered charcoal, $^1/_4$ inch thick or more, and mix thoroughly the melted ingredients by well stirring with a rod before adding a fresh metal. When completely melted and well mixed, remove the crucible or pot from the furnace, and while steadying it with the tongs, add 0·25 per cent by weight of bismuth, well stirring all the time of adding the bismuth, and then pour into the bearing mould. When making an alloy of four ingredients, melt three of them as above described, leaving out the bismuth, and pour into ingot moulds and store. When required, re-melt the ingots, add the remaining metal and also the bismuth, as above explained, and pour into the bearing moulds at once. Note, never cook the alloy by letting it remain in the pot in a melted state over the fire. Bismuth is very fusible and causes other metals to become fusible. It expands in cooling.

In forming an opinion of the suitability of an alloy for bearing purposes, it is convenient to know something about its hardness. Messrs. Calvert and Johnson tested the hardness of a large number of metals and their alloys by the amount of indentation made by a steel point under a known pressure, taking the hardness of Staffordshire cold-blast grey No. 3 cast iron equal to 1,000 as the maximum hardness for comparison. But as an alloy's hardness is dependent upon its fusion point, the proper atomic proportion of its constituents, the thoroughness of the mixing and pureness of the elements in the compound, its comparative hardness can only be accurately determined by direct test. But a very close approximation to this test hardness may be obtained by an empirical formula, and to facilitate its application, the author has compiled by a tentative process the diagram chart No. 2. The horizontal lines at the top half of chart represent the percentage of an element in a binary alloy minus 50, and their inter-sections with the corresponding curves are denoted by numbers arranged horizontally in the middle of the chart; these numbers multiplied by the reduced percentage has to be added, or they may be regarded as plus numbers. The lines in the lower half denotes 50 minus the percentage of an element in a binary alloy, and the numbers in the middle of the chart, corresponding to the inter-sections of the horizontal lines with the curves, give values which, multiplied by the reduced percentage, has to be subtracted, or may be regarded as numbers having the minus sign affixed. It has to be noted that two curves are given for copper; the one marked " copper " is to be used when any combining element in the alloy other than tin is made use of. When tin is the combining element, make use of the other curve named " copper in alloy with tin." Further, the lines in full give results accurately corresponding to the test results made by Calvert and Johnson, while the prolongation of the curves, and the antimonial and other curves, have been indicated by dotted lines, to show that their construction is by theory, ihe author not yet having time to get proof of their accuracy. But it may be safely assumed that they give results within 5 per cent of an actual test.

To find the relative hardness of a binary alloy :

1° Multiply the constant number 50 by the combining value of the alloy's constituents given in table I, calling the sum of the results, for direction, the tabular number;

2° Express the atomic weights of the alloy's constituents as a percentage of they alloy;

3° Take the larger percentage and find its correct value from the top half of the chart, as previously explained, and add the value to the tabular number;

4° Take the lesser percentage and find its correct value from the lower half of the chart and subtract the result from the tabular number. The remainder will be the alloys hardness with respect to cast iron.

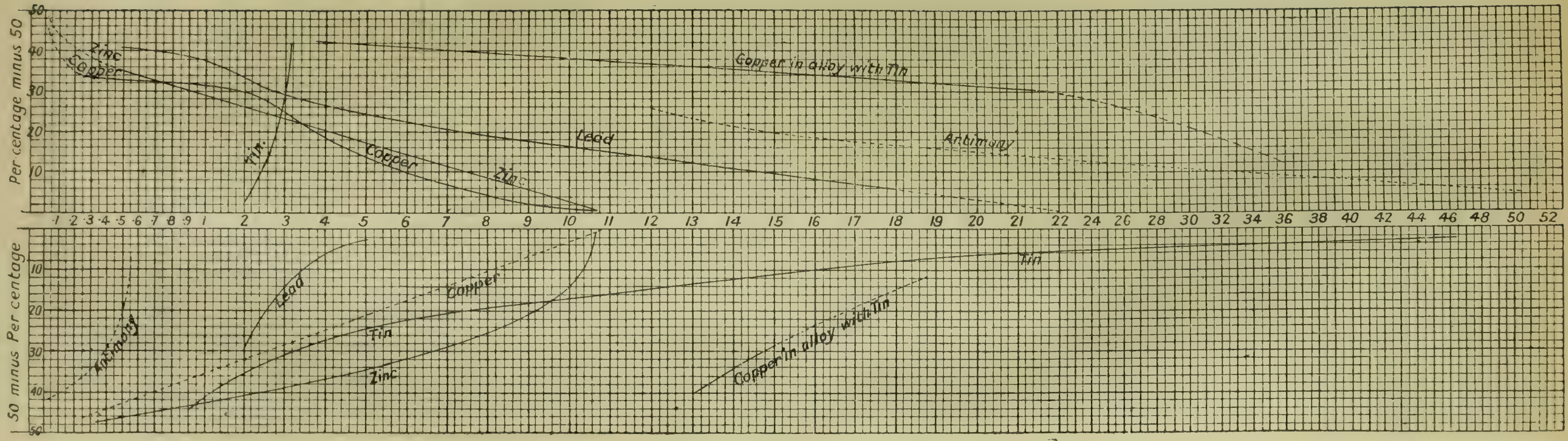

Fig. 2. — Chart No. II. Hardness of Alloys.

TABLE II. — *Alloy table.*

—		Chemical equivalents					By weight.					Weight per cent in alloy.					Relative Hardness cast iron = 1,000 calculated.
		Copper.	Tin.	Zinc.	Lead.	Antimony.	Copper.	Tin.	Zinc.	Lead.	Antimony.	Copper.	Tin.	Zinc.	Lead.	Antimony.	
BRONZE.— Copper and tin, known as gun-metal.	Very hard bronze	12	1	...	...	...	762	118	...	...	...	86·5	13·5	...	...	...	× 907
	Hard bronze for machinery bearings	14	1	...	...	...	889	118	...	...	...	88·2	11·8	...	...	...	× 789
	Bronze somewhat softer	18	1	...	...	...	1,143	118	...	...	...	90·6	9·4	...	...	...	×
	Soft bronze for toothed wheels	20	1	...	...	...	1,270	118	...	...	...	91·4	8·6	...	...	...	×
BRASS. — Copper and zinc	Malleable brass	4	...	1	...	...	254	...	65·2	...	...	79·5	...	20·5	...	...	× 452
BABBITT'S MIXTURES.— Copper, tin and zinc	Babbitt's genuine	1	12	...	...	1	63·5	1,416	...	...	120	3·96	88·5	...	...	7·5	×
	— softened with 11 per cent of lead	1	12	...	1	1	63·5	1,416	...	207	120	3·5	78·3	...	11·4	6·6	×
	— for propeller bushes	...	...	...	...	...	...	...	...	...	...	5	26	69	...	...	...
	— for quick-running machinery	...	...	...	...	...	...	...	...	...	...	84	...	16	...	...	...
	— anti-friction metal	...	...	...	...	...	...	...	...	...	...	6	14	80	...	...	...
WHITE METALS, LINING DO., ANTI-FRICTION ALLOYS. — Copper and tin with antimony or lead.	Hard anti-friction metal	...	...	...	...	...	...	...	...	...	...	10	74	...	...	18	...
	Tough anti-friction metal	...	...	...	...	...	...	...	...	...	...	7·5	58	...	...	7·5	...
	Quick-running machinery bearings	...	...	...	...	...	...	...	...	...	...	6	17	...	...	77	...
	Engine bearings	...	...	...	...	...	...	...	...	...	...	12	78	...	...	10	...
	— — with lead	...	...	...	...	...	...	...	...	...	...	4	81	...	5	10	...
	Bearings for heavy work	...	...	...	...	...	...	...	...	...	...	2	90	...	...	8	...
	— for light work	...	...	...	...	...	...	...	...	...	...	5	85	...	...	10	...
	Great Eastern Railway	3	23	...	...	3	190·5	2,714	...	...	360	5 83	83·13	...	...	11·03	× 694
ANTI-FRICTION ALLOYS AND LINING METALS.	Magnolia. Hirn's *Metallurgy of Alloys*	...	2	...	14	5	...	236	...	2,898	600	...	6·3	...	77·6	16	× 584
	Excentric straps	...	...	...	...	...	...	...	...	...	...	...	10	...	70	20	...
	Metallic rod packing	...	...	...	...	...	...	...	...	...	...	...	12	...	80	8	...
	Bearings of shafting	...	...	...	...	...	...	...	...	...	...	...	38	...	40	22	...
	— —	...	...	...	...	...	...	...	...	...	...	...	6	...	14	80	...

In a similar manner, the chart may be made use of for finding the hardness of an alloy composed of more than two elements; thus, let the chemical equivalents of the alloy be represented by A, B, C, D, etc., of which let A be the greatest number. Divide A by the number of elements minus one, and form them into pairs, thus :

$$\frac{A}{3} + B, \frac{A}{3} + C, \frac{A}{3} + D, B + C, B + D, C + D.$$

Find the hardness of the alloy represented by each pair of elements in the manner explained and divide the sum of their hardness by the number of pairs.

Example 1. — Hard bronze for machinery bearings consisting of the

Chemical equivalents	Copper	14
	Tin	1
and		
Weight per cent in alloy	Copper	88·2
	Tin	11·8
Tabular number = 50 × 9 + 50 × 0·6	=	480
Copper (88·2 — 50) × 9·6 from chart	=	366·7
Tin (50 — 11·8) × 1·5 from chart	=	— 57·3
Calculated hardness	=	789·4

Example 2. — Malleable brass.

Chemical equivalents	Copper	4
	Zinc	1
and		
Weight per cent in alloy	Copper	79·5
	Zinc	20·5
Tabular number = 50 × 9 + 50 × 3	=	600
Copper (79·5 — 50) × 2 from chart	=	59
Zinc (50 — 20·5) × 6·8 from chart	=	— 206·6
Calculated hardness	=	452·4

Example 3. — Antimonial lead alloy in use on the Pennsylvania Railway.

Chemical equivalents	Lead	4
	Antimony	1
Weight per cent in alloy	Lead	87·3
	Antimony	12·7
Tabular number = 50 × 0·2 + 50 × 14	=	710
Lead (87·3 — 50) × 1 from chart	=	37·3
Antimony (50 — 12·7) × 0·2 from chart	=	— 7·4
Calculated hardness	=	739·9

This alloy costs the least to produce; it is about as hard as bronze, but brittle, whereas bronze is very tough. It is inferior in wear-resisting properties; a small amount of tin added to this alloy would impart to it rigidity or toughness, and render it suitable for bearings with unit-bearing pressures, but at the same time increasing its cost of production.

The well-know brand " Magnolia " is an antimonial lead compound, with a small addition of tin, and its success as a bearing alloy is in all probability due to its method of manufacture. Hirn, in his book, gives its analysis as lead 78, antimony 16, and tin 6, from which can be easily obtained its chemical equivalents as lead 14, antimony 5, tin 2. Dividing these into three pairs, as already described, we obtain in

Chemical equivalents	Lead, 7; antimony, 5. Lead, 7; tin, 2. Antimony, 5; tin, 2.
Equivalent weight per cent	Lead, 70·7; antimony, 29·3. Lead, 85·9; tin, 14·1. Antimony, 71·7; tin, 28·3.
Hardness of each compound separately . . .	Lead and antimony, 844·5. Lead and tin, 21·8. Antimony and tin, 886·1.

The sum of the hardness of these pairs divided by 3 = 584·1, which is about the average hardness of bearings for line shafting.

The proportions of the constituents in the white metal know as Babbitts is stated differently in almost every list of bearing alloys compiled by various authors, but the following proportions are perhaps is near like the original as can be obtained. They are, in chemical equivalents : tin 12, antimony 1, copper 1. Dividing into three pairs as before, we obtain in

Chemical equivalents	Tin, 6; antimony, 1. Tin, 6; copper, 1. Antimony, 1; copper, 1.
Equivalent weight per cent	Tin, 85·5; antimony, 14·5. Tin, 91·7; copper, 8·3. Antimony, 65·3; copper, 34·7.
Hardness of each compound separately . . .	Tin and antimony, 830·5. Tin and copper, 646·8. Antimony and copper, 1,339·8.

The sum of the hardness of these pairs divided by 3 = 939. This is the most costly of white metal bearings. At the same time, being nearly anti-corrosive, any kind of grease may be used, and given fair alignment, and not excessive unit pressure, a bearing of the above mixture has a long life.

The above examples sufficiently illustrate the use of the chart for finding the approximate hardness of a bearing alloy. How hard it should be is a matter of experience. In general practice, the hardness as found above should be an amount at least equal to or a little in excess of the unit-bearing pressure, in pounds per square inch, except when such unit pressure, from special circumstances, is intended to exceed 900 lb. per square inch of bearing surface. It is well to bear in mind that antimony should not exceed some 20 per cent and zinc 33 per cent in weight of the alloy, otherwise it will be brittle and liable to crack. For heavy mill, marine, and high-speed engine shafts with fair alignment, bearings of 900 hardness has been found to answer, but they are liable to heat if the bearings get a trifle out of line, so that it is safer practice not to let the hardness exceed 800. For connecting-rods and bearings subjected to knocks, 700 hardness answers well if the alignment can be maintained, but in locomotive connecting-rods the want of maintaining the alignment necessitates the softening down of the white metal to about 600 hardness. It is best practice to make such bearings of good bronze for toughness, and line them some $^{1}/_{4}$ or $^{3}/_{8}$ inch thick with the alloy or white metal. Bearings for line shafting may have a hardness of 550.

It has been stated that any kind of grease or oil may be used with the Babbitt's mixture already given, but when this is softened down with lead, or with any alloy having zinc and lead in its composition, care should be exercised in the selection of the oil used to lubricate it, as such selection forms a considerable factor in the life of the bearing. It is often a question of some importance in designing the commoner class of machinery — say, agricultural or coal elevating, for instance — whether to put in high price bearings, for which any kind of cheap lubricant may be used, or bearings at a less cost, yet, to be equally as efficient in the matter of wearing as long, would necessitate the use of a lubricant costing twice to three times as much as the lubricant necessary in the higher price bearings.

The general principle to be observed in the manufacture of an alloy, as being essential to its soundness, strength, and durability, consists in making the quantities of its constituents bear definite atomic proportions to each other. If this principle be not observed, our subsequent careful handling of the alloy will be completely wasted, for the metal produced would not be a homogeneous compound or alloy, but a mixture of two or more compounds in irregular masses, shown by a mottled appearance when broken.

Professor Rankine, in his book *Machinery and Millwork,* remarks that these "masses, being different in expansibility, elasticity, and chemical composition, tend to separate from each other, setting up electric circuits and promoting corrosion." It is an utter impossibility correctly to harden or soften down an alloy in which the proportions the constituents bear to each other are unknown. Table II gives the chemical equivalents of the metals that usually make up the commercial alloy constituents. For example, the bronze, of which the hardness has been calculated, is given in

	Chemical equivalents.			By weight.			Weight per cent in alloy.	
as	Copper . .	14	and is	Copper . .	762	and equal	Copper . .	88·2
	Tin . . .	1		Tin . . .	118		Tin . . .	11·8

Suppose it is required to soften down Babbitt's mixture, the composition of which has been given. The least relative quantity of lead that can be added is the chemical atom 1, and the composition would then read thus, in

	Chemical equivalents.			By weight.			Weight per cent in alloy.	
as	Tin . . .	12	and is	Tin . . .	1,416	and equal	Tin . . .	78·3
	Antimony.	1		Antimony.	120		Antimony.	6·6
	Copper . .	1		Copper . .	63·5		Copper . .	3·5
	Lead . . .	1		Lead . . .	207		Lead . . .	11·4

Suppose it is desired further to soften the mixture by adding 2 atoms of lead, so that the composition would read in

	Chemical equivalents.			By weight.			Weight per cent in alloy.	
as	Tin . . .	12	and is	Tin . . .	1,416	and equal	Tin . . .	70·3
	Antimony.	1		Antimony.	120		Antimony.	5·9
	Copper . .	1		Copper . .	63·5		Copper . .	3·1
	Lead . . .	2		Lead . . .	414		Lead . . .	20·5

And no other method but the above will give the correct amount of lead to be added. Suppose in 100 lb. of this softened Babbitt's mixture something less than 11 lb. of lead had been added, or say it contained lead to the extent of 15 lb., then the pot containing the alloy in the molten state would have some 3·6 lb. of lead unalloyed or in a free state, probably in a mass at the bottom, and some form of mechanical mixer would have to be devised to mingle the lead sediment with the alloy before casting the bearing, as the author has recently heard of a leading firm doing, who, apparently unaware of the correct principle of mixing metals for alloying, designed a special apparatus for stirring up the lead sediment in the melting pot.

In conclusion, the author summarises the points he has enlarged upon, the observance of which is necessary for the making of a successful alloy.

1° The general conditions under which the white metal bearing will be worked as forming the determining factor in the selection of a suitable alloy;

2° The unit pressure on bearing as determined by the velocity of the journal circumference can be fixed;

3° The selection of the constituents with reference to their non-corrosiveness or anti-friction qualities;

4° The proper proportions for their alloying or combining can be determined;

5° The hardness of the selected alloy can be ascertained by figures sufficiently accurate, without recourse to experiment, a result, as far as the author is aware of, now made public for the first time.

The list of alloys on table II is a selection principally from Hirn's *Metallurgy of Alloys*, with the hardness of a few compounds calculated out. As time has not permitted the author to check the complete list of compounds in reference to their chemical equivalents, bearing in mind that the latter must be whole numbers, it is advisable to do so before making a selection.

[656 .257.2]

MACHINE FOR PRINTING, ISSUING AND CHECKING RAILWAY TICKETS,

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Figs. 1 to 11, pp. 542 to 548.

(*Portefeuille économique des machines.*)

On those metropolitan lines of Paris, which are now open (Nos. 1, 2 Nord and 3), the tickets are printed and issued at each station by an electric machine, which is operated with the greatest ease by the ticket clerk in charge.

This machine is a printing-issuing-checking machine; its chief objects are :

1° To make it unnecessery to keep a stock of tickets at the stations, and consequently to eliminate all the work which keeping such a stock entails;

2° To print, number and date the tickets, as and when required by passengers;

3° To simplify as far as possible the book-keeping and the checking of the accounts.

The type of machine adopted on line No. 3 after preliminary trial on the Nord circular line, differs materially from the first type designed, and used on line No. 1. In the latter, the printing is effected by a reciprocating motion; practice has shown that although a very good impression is obtained, free from the shifting which may occur with rotary printing, the arrangement has the defect of being somewhat noisy, and this may prevent the clerk from hearing what the passengers say.

The " Appareil Contrôleur " Company, the inventors and manufacturers of the issuing machines used on the Paris Metropolitan system, have accordingly devised a new rotary printing machine which has been definitely adopted for the other lines.

This new machine which, as well as the older one, will be described in detail further on, much resembles it; but it is quite noiseless (there are no longer any blows produced by up and down motion); there are also a number of interesting improvements, particularly a release which automatically stops the machine if the card strip tears (the card used is in rolls, each roll containing enough card for about 2,000 tickets); the release also works if the roll of card becomes used up without the clerk having noticed it.

Moreover in the new type, there is a device for throwing out of action any of the four printing apparatus separately; another device locks the checking gear when the doors are opened (the clerk opens the front door when changing the hour, the date, and the ink supply; the back door is opened to introduce the front end of a new roll of card into the printing apparatus); in this way any fraud is made impossible.

The machine is very economical in use. The net cost of a ticket can easily be determined, as only the following items come into consideration :

1° Depreciation of machine : the manufacturer guarantees the machine for four years and keeps it in repair during this time;

2° Cost of card;

3° Cost of ink;

4° The expenses connected with the checking of the receipts; these expenses the machine reduces to a minimum.

The cost of the electricity is negligible (maximum, 150 watt-hours per machine); the cost of the actual printing only amounts to 15 centimes (1 1/2 *d.*) per 1,000 tickets.

Against this cost, we must set the receipts for advertisements on the back of the tickets; these advertisements may well bring in 75 centimes (7 1/2 *d.*) per 1,000 tickets. They can thus pay at least for the card and the ink.

Consequently, a thousand tickets properly checked, only cost a few centimes; they may even yield an appreciable profit if the advertisements on all the tickets bring in 75 centimes (7 1/2 *d.*) per 1,000 or more. In such a case, the prime cost of each machine is quickly covered, and each station is provided with an issuing system which can satisfy all requirements in the way of speed and ease of control. We may add that additional checks can be easily used, so that the checks may counter-check each other; such as having at each entrance to the platform a small shearing machine to clip off the bottom end of the ticket and half the name of the issuing station; these halves then fall into a sealed box out of which they are taken at fixed intervals by special employees. The advertisements printed continuously on the back are also a safeguard, and if there are no advertisements, the back of the card may have a special design printed on it, for instance, simple diagonal lines, irregularly pitched at regular intervals; thus any fraud, of whatever kind, is practically impossible.

The numbers of the tickets always run from 1 to 100,000 and then begin again at 1 without break.

Putting up the machine at a station is a very simple operation; it is brought ready fitted and placed about 10 centimetres (4 inches) to the left of the booking office window; a plug with two contacts, connected with the machine by the usual flexible wire, is inserted in the main electric light circuit of the booking office at a place provided for the purpose, and the machine is then ready. A one-ampere fuse prevents any chance of accident.

In order to change the speed at which the machine works, the driving pulley of the motor is changed. This is a more convenient method than that first adopted on line No. 1, which was based on the action of rheostats, a very delicate mechanism which frequently failed; and these rheostats were taken out when the first machines were altered.

The series motors at present used are adjusted so as to print from 90 to 100 tickets per minute, when there is an average pressure of 525 volts; they only require 0·3 ampere when working, and the energy consumed is exactly proportional to the number of tickets issued.

The book-keeping of the office is exceedingly simple; the clerk enters on a special sheet the first number and the last number of each roll, when starting and when finishing work; three or four simple substractions show the number of tickets sold, and simple multiplications show what sums have to be paid over.

In fact, when these machines are used, the advantages are such that their prime cost is very soon covered, and the receipts are checked absolutely; the latter condition is of much importance as by the terms of the concession the Municipality of Paris is entitled to a share of the receipts.

Technical description of the machine.

A. *First type.* — This pattern was the one first used on line No. 1.

We give the following illustrations of this machine :

Fig. 1. — Vertical section of machine through *mn* (fig. 2);

Fig. 2. — Front view;

Fig. 3 and 4. — Two detailed views, on a larger scale, showing the upper part of the machine. Front view and side view.

In these illustrations, the same letters are always used for the same parts.

Two separate lots of type are provided; the first lot is for printing the inscriptions common to all the tickets; there are fixed characters for the print which is always the same, and movable characters, on the edge of disks, for the inscriptions which have to be changed, such as the date.

The second lot prints the number on each ticket; this number is increased by one each time a ticket is printed, as will be shown later on.

The second lot also includes the type for printing the lower part of the ticket, so that all that is necessary, if another series of tickets of a similar kind is to be printed, is to change this type.

The strip of card, which is to be cut up into tickets, is in a roll on shaft 6, and held in position by the two side pieces 7. It is pressed by the roller 9 against the driving drum 8 on the printing table *q* upon which the end of the strip of card rests.

This table *q* receives a vertical movement, so that it presses the card against the type. It is for this reason fixed to a vertical rod *p* connected with the lever *r* which can rotate about *s* and carries a roller which runs in the groove of cam *t*; the latter forms one of the sides of the toothed wheel *u*.

The rod *v* is provided as an additional guide for the vertical movement of the table.

The cam *t* is rotated by the main shaft *w* by means of the pinion *x* which gears into the teeth of wheel *u*.

The shaft *w* as actuated by shaft *y* of the motor; pinion *x* is loose on shaft *w* and carried round by the latter by some suitable clutch, which can be thrown in or out of gear (fig. 2) by a lever *z*.

The inking roller 33 is carried by the two arms 32 which are connected with two bent levers 25 which can turn about *a*; these bent levers 25 are connected by the rods 37 with

Figs. 1 to 4. — *Machine for printing, issuing and checking railway tickets (first type).*

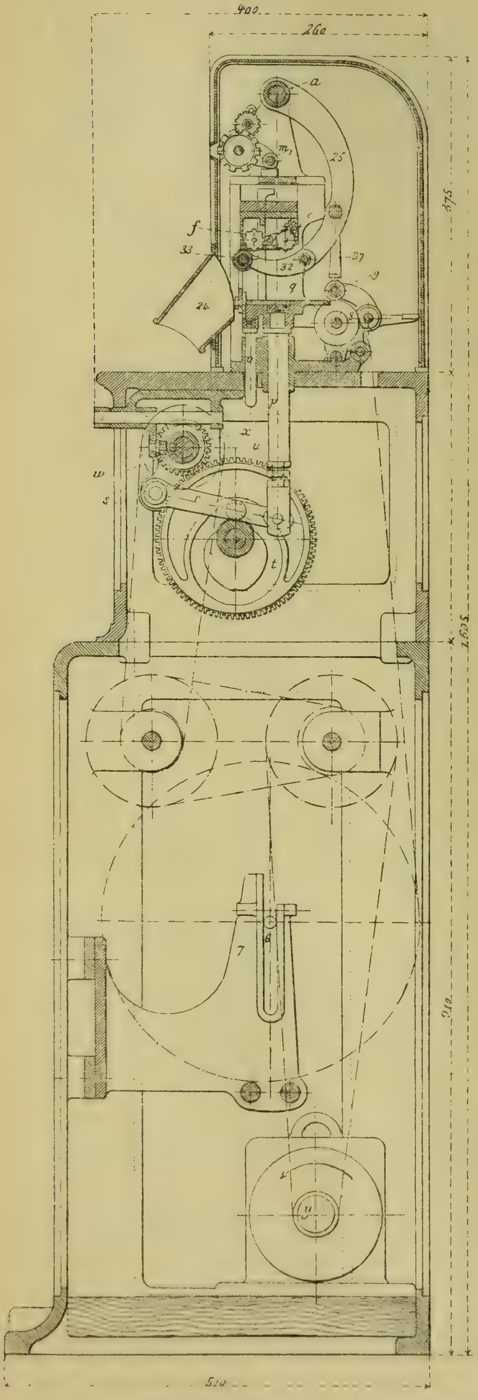


Fig. 1. — Vertical section through *mn*. (Fig. 2).

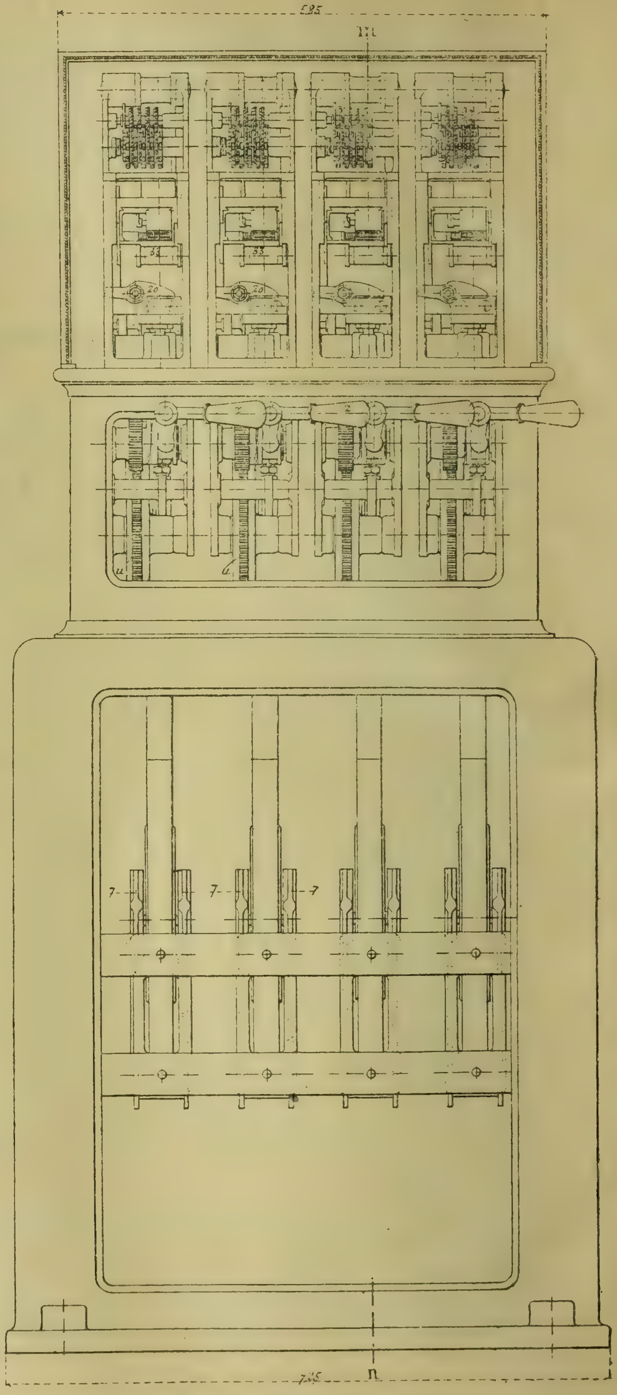


Fig. 2. — Front view. (General.)

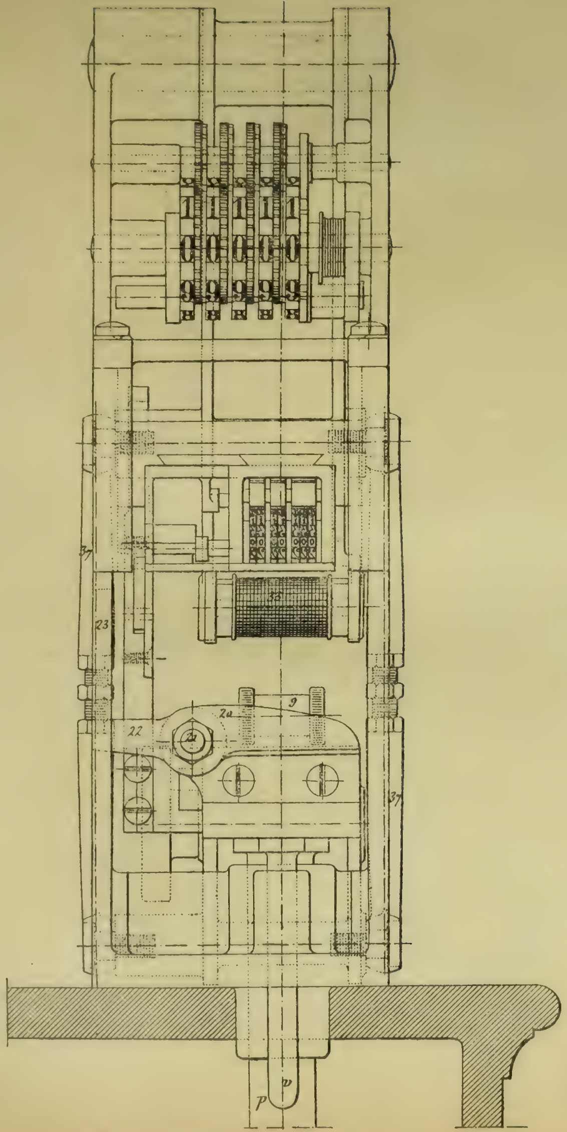


Fig. 3. — Front view (details of upper part).

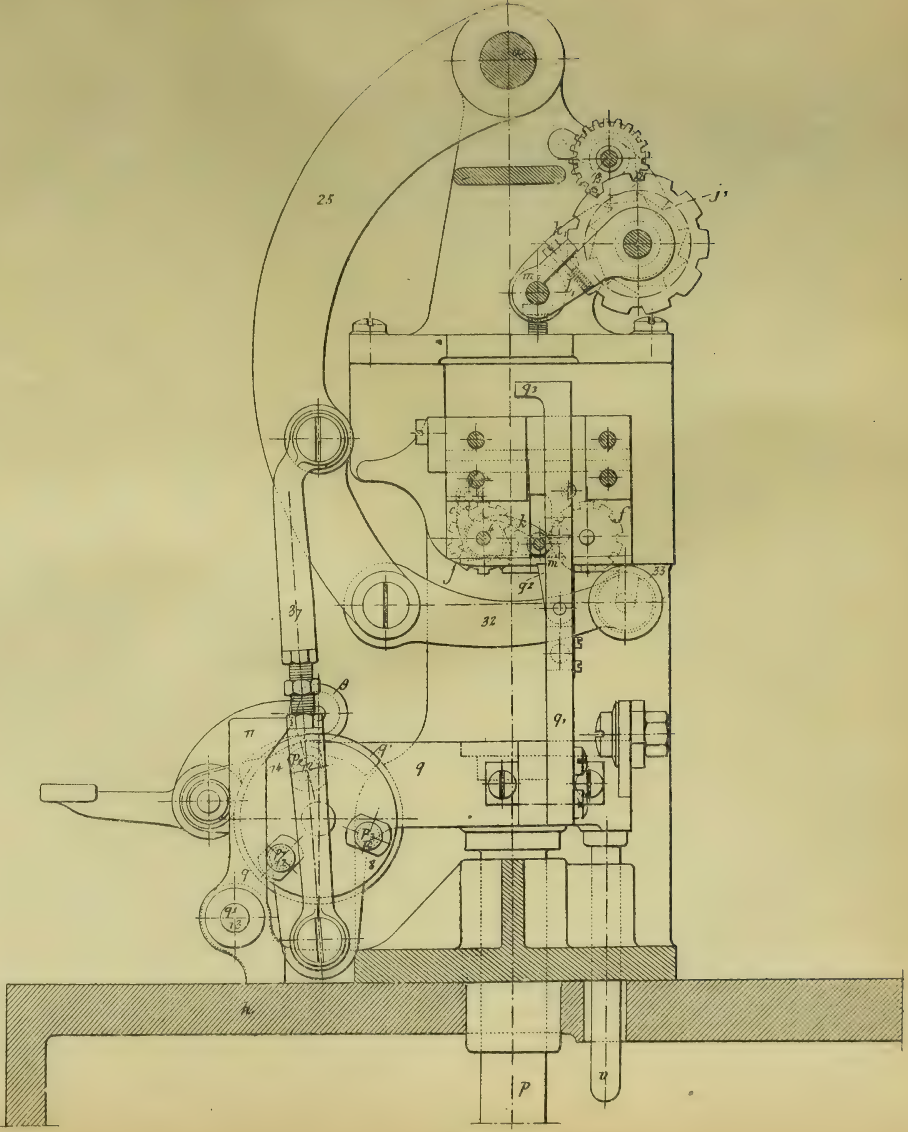


Fig. 4. — Side view (details of upper part).

the table q, so that the latter, when it rises, turns the levers about a (fig. 4), and the inking roller 33 is carried to the back clear of table q which can then press the card against the type.

Table q carries the upright q^1 which in its upward movement advances the number on the printing wheel by one, and also operates a visible counter fixed to the upper part of the machine; this counter helps to check the number of tickets issued.

The two units disks of the printing wheel and of the counter have each a ratchet jj^1, with a pawl kk^1 hinged to the arm ll^1 which can turn freely on the spindle of the wheels.

The arms ll^1 each have a rod mm^1 which is pushed upwards by the upright q^1 when the table q rises; the upright q^1 is for this purpose fitted with the spring catch q^2 and the projection q^3, which act, during the upward movement only, on the rods m and m^1 respectively.

Under these conditions, each time the table q rises in order to print a ticket, the upright q^1 turns the arms ll^1 on their axes, and the pawls kk^1 advance the ratchets jj^1 one division, and consequently, the units disks of the printing wheel and of the counter to which the ratchets are fixed.

Each revolution of these units disks advances the tens disk one division; similarly, the tens disk actuates the hundreds disk, and so on.

The different disks, both in the printing roller and in the counter, are so arranged that it is impossible to move any of them by hand.

Each disk has a small projection which, when the disk makes one complete revolution, acts on a star wheel fixed to a small pinion gearing into a toothed wheel fixed to the next disk.

In order to prevent the ratchet of the printing wheel or of the counter from being tampered with, when the machine is not at work, the actuating upright q^1 may be fitted with two stops which make it impossible to raise the pawls kk^1 when the table is in its lowest position; when the machine is working, these stops rise with the upright q^1 and no longer interfere with the lifting of the pawls kk^1.

The card strip feed is operated by the table in its downward movement.

The feed drum 8 has on the one side three projections 12 acted on in succession by a spring catch 11, which can turn about the centre 13 fixed to the frame of the apparatus.

A spring catch 14 prevents any backward movement of the drum 8.

When table q rises, one of the projections 12 pushes back catch 11, and passes up over it, and the catch springs back to its original position. When the table descends, projection 12 takes against catch 11 and compels the drum to turn until the projection is once more clear of the catch.

The drum thus each time makes a third of a revolution, and advances the strip of card the length of a ticket.

The strip of card, when it has been printed, is thus advanced the length of a ticket; then the ticket is cut off by means of shears. One of the blades of these shears, blade 20, can turn about the axis 21 and together with lever 22 forms one piece. The end of lever 22 works in slide 23.

The shears are thus opened and shut by the pressure of lever 22 against the top stop and the bottom stop of the slide.

The cut-off ticket falls out through opening 24.

The machine when set up is operated as follows :

The clerk presses on lever *z*; this sets all the mechanism in action.

The table *q* rises and in doing so throws the inking roller 33 backwards; during its passage the latter inks the type; the upright q^1 successively moves the arms *l* and l^1 and thus advances the units disks of the printing wheel and of the counter one division; then table *q* presses the strip of card against the type and so prints the ticket; towards the end of the upward movement of the table, the lever 22 of blade 20 takes against a stop so that the shears open.

The ticket being printed, table *q* descends; during this descent, projection 12 meets catch 11, drum 8 turns one third of a revolution and advances the strip of card the length of a ticket, the inking roller 33 is brought back to its original position shown in figure 4, being turned during its passage by coming in contact with the type; finally, lever 22 of blade 20 comes against the bottom stop of the slide; the shears close, the ticket is cut off and falls out through opening 24.

B. *Second type.* — This machine has been adopted, as already stated, not on line No. 1, but on the other lines, after preliminary trial on line No. 2 Nord; its distinguishing features are the special devices for printing on the strip of card and feeding it and the way in which the shaft operating the apparatus acts.

The printing is effected by a rotary cylinder which transmits a rotary movement to the drum which feeds the strip of card, only while the printing is done. The drum is stopped during the rest of the revolution of the cylinder.

This device ensures the proper feeding of the card strip, without any risk of breaking it; moreover, the printing is effected without any blow and without any noise.

The main shaft of the machine is actuated by an electric motor, the circuit of which is closed by pressure on the operating handle; the circuit is cut automatically when the handle re-assumes its initial position; so that the motor cannot run when there is no work to do, and electric energy cannot be wasted uselessly.

Figures 5 and 6 show respectively a vertical section and a front view of the machine. In both figures the same letters are used for the same parts.

The machine has a table *a* carried on a cupboard *b*. On the table, there are as many stands *c* as there are different kinds of tickets to issue, in this case four. The mechanism for printing, checking and issuing the tickets is the same for each kind of ticket; we therefore only describe one.

Each stand *c* has a cylinder *d* between the sides of which are fixed, next to each other, two lots of type *e* and *f* which together form a sector of the circumference of the cylinder, say one fifth of it, for instance; the first lot *e* prints the name of the company, the date, the class and the price; the second lot *f* prints the name of the issuing station and the number of the ticket. Fixed type is used for the inscriptions which are the same on each ticket, and movable characters, on the edges of disks, for those which vary. In lot *e*, the disks which print the date are operated by hand, in lot *f*, the disks printing the number are advanced automatically. With this object, rod *g* which acts on the units disk by means of a ratchet takes against a stop *h* fixed to stand *c*, when the cylinder *d* turns; rod *g* being stopped and the cylinder *d* continuing its revolution, rod *g* is subjected to an angular displacement relatively to cylinder *d*, and the units disk turns until rod *g* is clear of stop h; the angle through which it turns equals one tenth of a revolution, that is to say, one unit; the units disk in its turn acts on the tens disk, the tens disk on the hundreds disk, and so on, by means of the usual star wheels and gearing.

The type is inked by the porous roller i which is supplied with special printing ink. This roller is kept pressed against the edges of cylinder d by the framing i^1 which is pivotted to the support i^2. During the rotation, the right and left edges of this roller roll on the edges of the cylinder, and when the sector containing the type comes opposite the roller, it is inked.

Below the cylinder d is a rubber roller j which regulates the pressure required for the printing.

The axle d^1 of the cylinder d actuates the feed drum k as follows :

This axle d^1 has a pinion l, which transmits, by means of the pinion m and the toothed sector n, an angular movement to the pinion o which is fixed on the same shaft k^1 as feed drum k. The toothed sector n is so fixed that the drum k feeds the card strip p during the whole time of the printing.

In order that the angular movement of the feed drum k may be definite in amount and correspond exactly to the length of a ticket, a star wheel q is fixed to the feed drum; this star wheel is rendered immovable, except during the printing, by the disk r which is fixed to the same shaft as the toothed sector n; this disk r has a notch s to allow the angular movement of the star wheel q at the moment when the toothed sector n comes into gear with the pinion o.

The feed drum k is consequently locked in position as long as the toothed sector n is not in gear.

A roller t keeps the strip constantly pressed against the feed drum k.

Axle d^1 of cylinder d has at its other end a sprocket wheel u with the chain v driving the sprocket wheel w which is fixed to the disk w^1, which has two projections w^2. This disk w^1 can turn freely on the main shaft x.

A clutch y is also placed on this main shaft x; this clutch can slide on the shaft and turns when the latter turns; the clutch can be displaced sideways by lever z fixed to the shaft z^1, to which the starting handle z^2 is also fixed.

On shaft z^1 there is also a lever l' which by means of rod 2 operates the bolt 3 which takes into the notch which disk w^1 has on its circumference; this locks the mechanism of the whole machine when it is at rest.

The sprocket wheel u has a crank pin u^1 with a connecting rod 4, which through lever 5 gives a vertical movement to rod 6; the latter has a slot 7 in it. The end of the lever of the movable blade of the shears 8, takes into this slot and is so operated; the upper end of rod 6 terminates in a fork 9 which during its movement acts on lever 10 of counter 11.

The roll of card is on a bobbin 12 which is on a support 13 right on the top of the machine, in full view of the ticket clerk.

The strip is led under drum k, against which it is pressed by roller t, then passes over rubber roller j and is cut off by shears 8.

The main shaft x drives the whole mechanism. This shaft can be turned by hand, by means of flywheel 14, but under normal conditions it is worked by electric motor 15 which starts automatically as soon as any one of the handles z^2 is pressed down. An arm z^3 is fixed on shaft z^1 of each handle for this purpose; this arm moves a bar 16 with an

Figs. 5 and 6. — *Machine for printing, issuing and checking railway tickets (second type).*

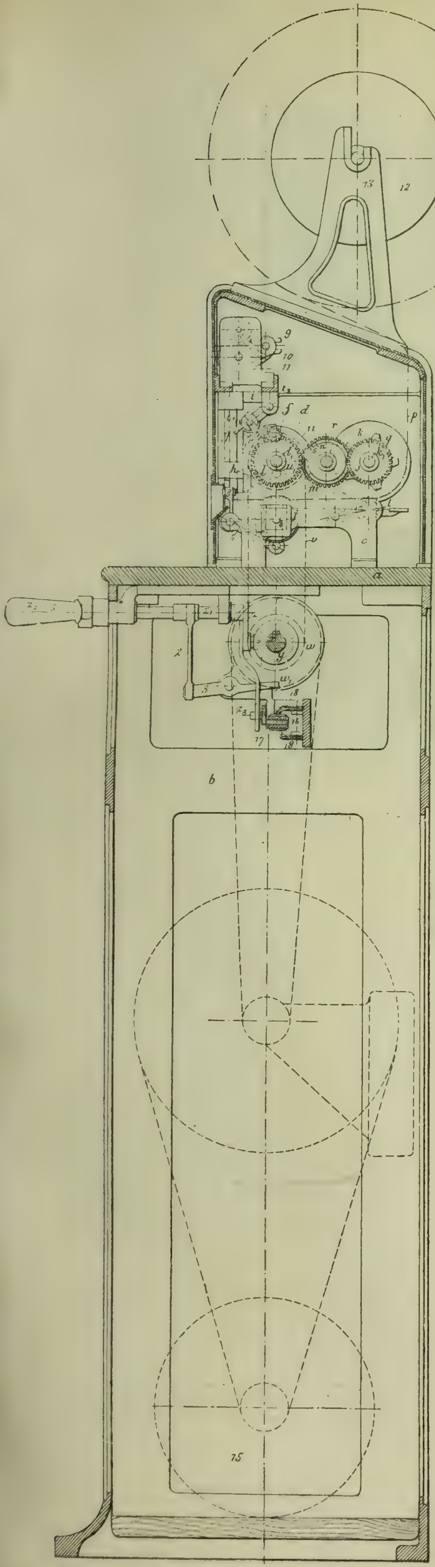


Fig. 5. — Vertical section.

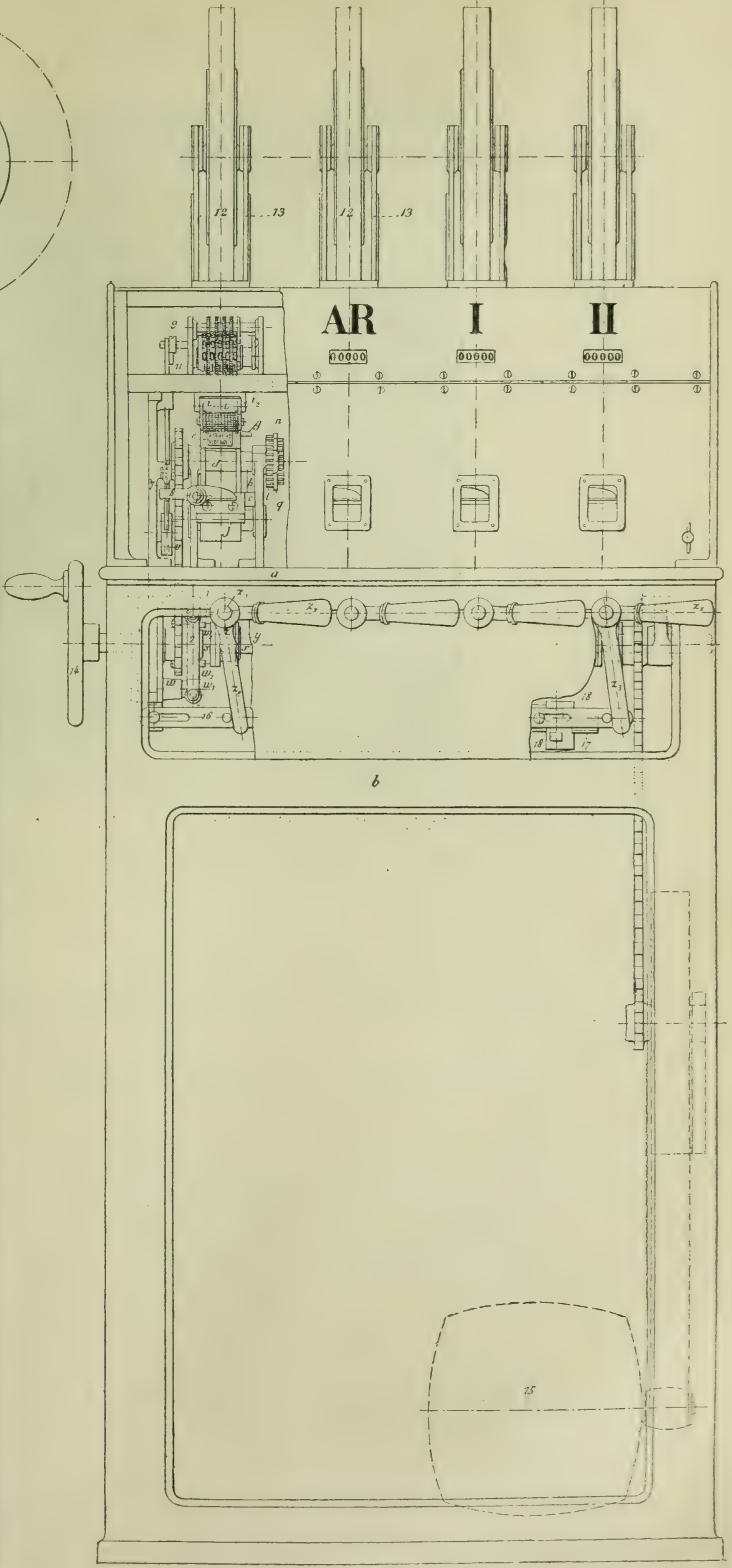


Fig. 6. — Front view.

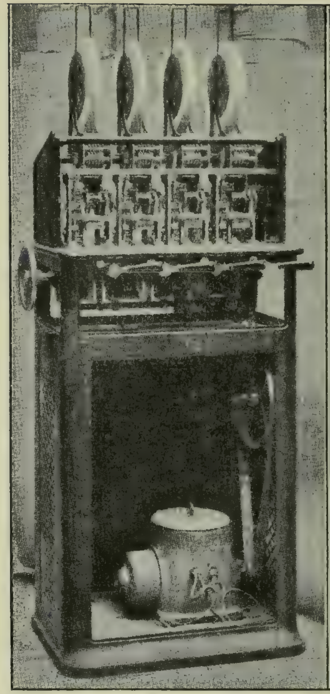


Fig. 7. — General view of machine (second type), cupboard door removed.

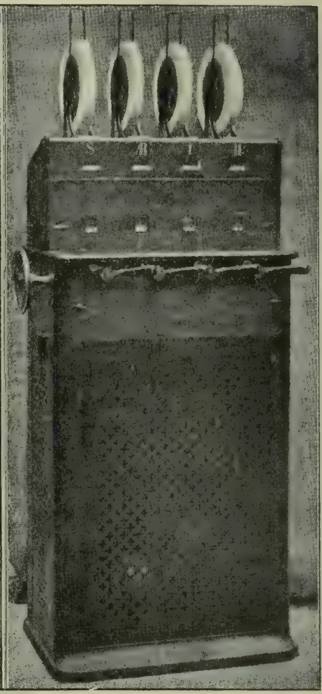
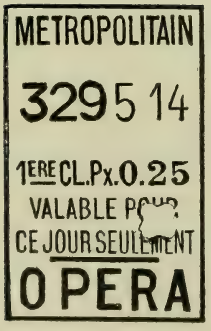


Fig. 8. — General view of machine (second type), cupboard door closed.



METROPOLITAIN

329 5 14

1ERE CL.Px.0.25

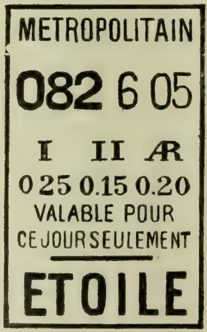
VALABLE POUR

CE JOUR SEULEMENT

OPERA

.71015.

Fig. 9. — First class ticket.



METROPOLITAIN

082 6 05

I II AR

0 25 0.15 0.20

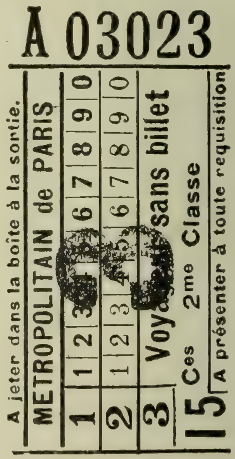
VALABLE POUR

CE JOUR SEULEMENT

ETOILE

01528

Fig. 10. — Extra ticket.



A 03023

A jeter dans la boîte à la sortie.

METROPOLITAIN de PARIS

1 | 1 2 3 4 5 6 7 8 9 0

2 | 1 2 3 4 5 6 7 8 9 0

3 | Voyageur sans billet

15 Ces 2me Classe

A présenter à toute requisition

Fig. 11. — Excess ticket.

electric contact 17 which goes between the brushes 18 when one of the handles z^2 is pressed down. The electric motor is in the bottom of the cupboard enclosing the lower part of the machine and transmits the movement to main shaft x, either directly or through gearing, according to the speed required.

The system works as follows :

In order to issue a ticket, the handle corresponding to the kind of ticket required must be pressed down; this starts the electric motor which turns main shaft x; bolt 3 is withdrawn and releases the mechanism; clutch y slides along main shaft x, locks into projections w^2 and makes disk w^1 turn.

Main shaft x then, by means of chain v, transmits a movement of rotation to cylinder d which in its turn transmits the movement to feed drum k when toothed sector n comes into gear with pinion o; at the same time rod 6 is moved downwards so that shears 8 open and allow the card strip to advance while the printing is going on.

Rod 6 in its downward movement pulls along with it lever 10 of counter 11, which is thereby advanced one.

When the ticket is printed, the printing cylinder d finishes its movement without any advance of the strip; for on the one hand the sector which does the actual printing and consists of the two parts e and f leaves the card which is then free between the two sides of cylinder d; on the other hand, the strip of card is held pressed between roller t and feed drum k, and the latter is prevented from moving by the star wheel q stopped by disk r as soon as toothed sector n is no longer in gear with pinion o.

The card being thus prevented from moving, rod 6 is given an upward movement by crank u^1 during the second half of the revolution, and closes the shears which cut off that part of the strip which has come out while feed drum k was turning; this forms the ticket.

During the whole operation bolt 3, in contact with the circumference of disk w^1, keeps clutch y locked into projections w^2 and contact 17 is between brushes 18 keeping the circuit closed during the whole time the operation lasts. When it is finished, bolt 3, acted on by a spring, shoots back into its notch; the clutch is released and the circuit broken, and rod 16 is brought back to its initial position by its spring.

If several tickets are to be printed and issued successively and without interruption, all that is required is to keep the handle pressed down while the tickets required are being printed.

When the machine is to be first started, *i. e.* when a fresh roll of card has been put in, the front end of the strip, which is introduced after disengaging the pressure roller t, comes against the closed shears. When the machine is then started, only that part of the card is printed on, which is behind the vertical plane through the axis of the printing cylinder. The first ticket cut off will consequently be a blank ticket, but it will be recorded by the counter. But on the other hand, before the new roll is put in, the end of the strip of the former roll will have to be pulled out; on this there is a ticket printed but not cut off, and not recorded by the counter. Consequently the two operations taken together give, correctly, the number of tickets printed.

In this second machine the roll of card, being at the top and not covered up, is visible to the clerk who can thus look after it more easily than in the first machine, in which it is inside the cast iron cupboard, below the other mechanism. The different controlling devices, the printing roller and the counter, are entirely independent of each other; they are arranged so that it is quite impossible to tamper with them, at least without breaking the lead protection seals and taking the mechanism to pieces.

Among other advantages of this machine, the following may be mentioned :

The cost of the second machine is materially less than that of the first machine, because what fitting has to be done is nearly all lathe work; maintenance is more easy because the number of working parts is much reduced and the clutch less complicated; the output of the machine can be much increased, if required, without affecting its reliability.

Figures 7 and 8 show views of the machine; the former with doors removed to show the mechanism, the latter in its normal closed condition.

Patterns of tickets used. — Tickets issued at any one station of the Paris Metropolitan are available to any other station of the system, no matter by what lines the passenger has to travel to reach his destination; therefore the name of the issuing station only is given on the ticket. It is this peculiarity, which results in great simplification, which makes it possible to use the machines described above.

There are four types of tickets, corresponding to the four divisions of each machine, namely (fig. 8) :

Division S	Extra tickets;
— AR	Return tickets;
— I	First class tickets;
— II	Second class tickets.

The return tickets, and the first and second class tickets, measure 56 by 31 millimetres (2 3/16 inches by 1 7/32 inch). They are of similar pattern (fig. 9); the only difference is the inscription, being the class and the price. The figures on the second line give three separate numbers, the first for the date, the second for the year (the last figure only of the year) and the third for the hour of issue (the hours are numbered 1 to 24, from midnight to midnight). The figures on the bottom line are the number of the ticket, each lot of tickets running from 1 to 100,000 successively. These are different figures, which together with the name of the station, serve for checking the ticket issue. Thus the ticket shown in figure 9 is a first class ticket, fare 25 centimes (2 1/2 *d.*); it was issued at the "Opera" station on November 25, 1905 (329th day of year 5), at 2 p. m. (14th hour of the day), and is numbered 71,015. The first class tickets are pink card, the second class tickets white and the return tickets green with pink stripes. (Only second class return tickets are issued; fare, 20 centimes [2*d.*]. See tariff of concession, chapter IV, article 23, paragraph 3.)

Division S is used for extra tickets, if for any reason one of these other divisions is not in working order.

These extra tickets are of a pattern similar to that just described, but have one common inscription for all classes and fares (fig. 10); whether the ticket is first, second or return is shown only by the colour of the card, the same distinguishing colours being used as in the ordinary tickets.

Besides the tickets just described, there are other kinds also in use on the Paris Metropolitan. The following are their names and descriptions :

Passengers are bound by the regulations to produce their tickets when requested to do so by an official of the company. Any passenger who fails to do so, whether because he has lost his ticket or because he has not taken one, must pay his fare according to class of carriage; hence two varieties of tickets, first and second, for passengers who are on the train without tickets. This pattern of ticket is shown in figure 11; the first class ticket is pink and the second class white. The figures on it are for checking purposes and do not concern the passengers.

Then also passengers may be travelling in the first class and have second class tickets (single or return). Three varieties of ticket are provided for this case :

1° Excess fare of 10 centimes (1*d.*) for a passenger travelling first class and having a second single ticket (blue excess ticket);

2° Excess fare of 5 centimes (1/2*d.*) for a passenger travelling first and having a whole second return ticket (brown excess ticket);

3° Excess fare of 15 centimes (1 1/2 *d.*) for a passenger travelling first and having a second return half (yellow excess ticket).

These three varieties of ticket are like those for passengers without ticket except that instead of "voyageur sans billet" (passenger without ticket) there is "Bulletin de perception supplémentaire" (excess fare ticket).

Finally other tickets known as "reserve" tickets are printed in advance and stocked at the stations; the clerk are responsible for their custody. They are only to be used when the issuing machine is so badly damaged that it no longer works. Pending repairs, the clerk utilizes the reserve tickets, printing on them by means of a hand stamp, as they are required, exactly the same date, year and hour figures as are on the machine tickets; they differ from the latter in the colour of the card : first, salmon; second, cream; return, half green, half violet.

In order that regular passengers may not be kept waiting at the booking offices during busy times, the Paris Metropolitan sells, at every station, packets of first and of second class tickets; each packet contains ten tickets and is sold without reduction (*i. e.* it costs ten times as much as the corresponding single ticket). These tickets are available for three months from the date of issue; the date is stamped on the cover of the packet.

In conclusion, we may remark that the sums payable to the Municipality of Paris by the company are based on the number and price of the tickets issued by the latter; for more details on this particular point, see article 19 of the concession (1).

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(1) See *Le Chemin de fer métropolitain municipal de Paris*, by J. HERVIEU, appendix B.

[656 .222.1 (.431 + .73)]

TRAIN SPEEDS ON AMERICAN AND GERMAN RAILWAYS,

By W. A. SCHULZE.

(Abstract.)

(Mr. W. A. Schulze has recently published two articles, in the *Archiv für Eisenbahnwesen* and in the *Zeitung des Vereins deutscher Eisenbahnverwaltungen,* on the fastest trains in the United States and in Germany, of which we give the following summary.)

I. — American railways.

The author, taking as his authority the *Official Guide of the Railways and Steam Navigation Lines of the United States,* edited by W. F. Allen, New York, proceeds to enumerate the best trains of the different lines which connect, by the shortest routes, the ten chief cities, namely New York, Chicago, Philadelphia, Baltimore, Boston, Buffalo, Cleveland, Pittsburg, St. Louis and Washington; he adds the fastest trains running between Chicago and San Francisco and between Philadelphia and Atlantic City. The more remarkable performances mentioned in the author's article are as follows :

Boston-New Haven-New York (232 miles or 374 kilometres). — On this line, taking both directions together, there are twenty-four express trains every weekday. Six of these trains do the run in 5 hours, so that the inclusive speed is 74·8 kilometres (46·5 miles) per hour; stops excluded the mean running speed is 77·9 kilometres (48·4 miles) per hour, that on New Haven-New London section (51 miles or 82 kilometres) being 82 kilometres (51 miles) per hour and on the Providence-New London section (63·2 miles or 102 kilometres) 88·7 kilometres (55 miles) per hour. Then there are two trains taking 5 hours 30 minutes, the inclusive speed being 68 kilometres (42·3 miles) per hour, and six trains taking from 5 hours 55 minutes to 5 hours 59 minutes, thus having an inclusive speed of 63·2 to 62·5 kilometres (39·3 to 38·8 miles) per hour.

New York-Albany-Buffalo (439·5 miles or 708 kilometres). — The celebrated *Empire State Express* does this run at a mean running speed (stops excluded) of 87·6 kilometres (54·4 miles) per hour in the one direction, and of 80·3 kilometres (49·9 miles) per hour in the other. From New York to Albany (142·9 miles or 230 kilometres) it is allowed

2 hours 40 minutes (86·3 kilometres [53·6 miles] per hour); Albany to Utica (94·7 miles or 152·5 kilometres), 1 hour 37 minutes (94·3 kilometres [58·5 miles] per hour); Utica to Syracuse (53·2 miles or 85·6 kilometres) 1 hour 3 minutes (81·5 kilometres [50·6 miles] per hour); Syracuse to Rochester (80·4 miles or 129·4 kilometres), 1 hour 24 minutes (92·4 kilometres [57·4 miles] per hour); Rochester to Buffalo (68·4 miles or 110·1 kilometres), 1 hour 20 minutes (82·6 kilometres [51·3 miles] per hour); there is no stop in any of these sections. It is to be noted that the *Twentieth Century Express,* which will be mentioned later on, takes 1 hour 42 minutes in running the 94·7 miles or 152·5 kilometres from Albany to Utica (speed, 89·7 kilometres [55·7 miles] per hour) and that the three next fastest trains do this distance in 115, 117 and 118 minutes respectively, that is at speeds of only 79·6, 78·2 and 77·5 kilometres (49·5, 48·6 and 48·2 miles) per hour. The 439·5 miles or 708 kilometres from New York to Buffalo are run by the *Second Empire Express* and the *New York Express* at speeds of 77·5 and 72·9 kilometres (48·2 and 45·3 miles) per hour respectively (stops deducted).

Jersey City-Sayre-Geneva-Buffalo. — Passengers from New York cross the Hudson river by ferry-boat. The best train on this line is the *Black Diamond Express,* which does the distance (446·6 miles or 719 kilometres) in 10 hours 8 minutes in the one direction and in 10 hours 55 minutes in the other; the respective speeds (stops deducted) being 74·4 and 70·1 kilometres (46·2 and 43·6 miles) per hour. Newark to Easton (68·3 miles or 110 kilometres) Tunkhannok to Sayre (64 miles or 103 kilometres), Sayre to Geneva (73·5 miles or 118·3 kilometres), East Buffalo to Rochester (63·7 miles or 102·5 kilometres), take respectively 1 hour 19 minutes, 1 hour 17 minutes, 1 hour 25 minutes, 1 hour 8 minutes, the speeds thus being 83·5, 80·3, 83·5, 90·4 kilometres (51·9, 49·9, 51·9, 56·2 miles) per hour. In connection with the last section, East Buffalo to Rochester, it may be noted that the next fastest train runs from Buffalo to Rochester (68·1 miles or 109·6 kilometres) in 1 hour 25 minutes, the speed being 77·4 kilometres (48 miles) per hour; and that the *Black Diamond express* on the return journey takes 1 hour 28 minutes from Rochester to Buffalo, the speed being only 74·7 kilometres (46·4 miles) per hour.

New York-Albany-Cleveland-Chicago. — The distance is 963 miles or 1,550 kilometres; the *Twentieth Century Express* does it, in both directions, in 18 hours; stops deducted, the mean speeds are 87·3 and 87·7 kilometres (54·2 and 54·5 miles) per hour. We have mentioned above the run of this train between Albany and Utica; the following are some other sections in which there is no stop: Englewood to Elkhardt (94 miles or 151·3 kilometres), Elkhardt to Toledo (128 miles or 206 kilometres), Cleveland to Toledo (113 miles or 181·9 kilometres), Rochester to Cleveland (249·6 miles or 402 kilometres), Syracuse to Rochester (80·4 miles or 129·4 kilometres), Syracuse to Albany (148 miles or 238·1 kilometres), New York to Albany (142·9 miles or 230 kilometres) take respectively 1 hour 43 minutes, 2 hours 15 minutes, 2 hours, 4 hours 35 minutes, 1 hour 26 minutes, 2 hours 43 minutes, 2 hours 40 minutes, the speeds being 88·1, 91·5, 91, 87·7, 90·3, 87·6, 86·3 kilometres (54·7, 56·9, 56·5, 54·5, 56·1, 54·4, 53·6 miles) per hour.

Jersey City-Bound Brook-Philadelphia (90·2 miles or 145 kilometres). — The best train takes 1 hour 49 minutes on the outward and 1 hour 48 minutes on the return journey; the mean running speeds are respectively 82·1 and 82·9 kilometres (51 and 51·5 miles) per hour. Between Bound Brook and Wayne Junction (55·6 miles or 89·5 kilometres) it runs at a speed of 91 kilometres (56·5 miles) per hour; between Elkins Park and Jersey City (80·9 miles or 130 kilometres), one of 87·6 kilometres (54·4 miles) per hour. There are three stops, of one minute each, between Jersey City and Philadelphia.

Jersey City-Trenton-Philadelphia (84 miles or 135 kilometres). — The quickest train on the outward journey stops at Trenton, on the return journey at Newark, the stops are one minute each. Mean running speeds, 88 and 86·2 kilometres (54·7 and 53·6 miles) per hour; mean speed from Jersey City to Trenton (55·7 miles or 89·7 kilometres) 88·2 kilometres (54·8 miles) per hour; from Philadelphia to Newark (76·3 miles or 122·8 kilometres), 89·9 kilometres (55·9 miles) per hour.

The Central Railroad of New Jersey, and the Philadelphia & Reading, run every weekday between New York and Philadelphia, taking both directions together, forty express trains; the Pennsylvania runs no less than seventy-eight expresses every weekday between the same two points. On the former forty trains, the thirteen best, between Jersey City and Philadelphia via Bound Brook (90·2 miles or 145 kilometres), take between 108 and 109 minutes, the inclusive speed being 80 kilometres (49·7 miles) per hour. As for the Pennsylvania trains, which run between Jersey City and Philadelphia via Trenton (84 miles or 135 kilometres), there is one which takes 93 minutes, an inclusive speed of 87·1 kilometres (54·1 miles) per hour; two others take 95 minutes, speed 85·3 kilometres (53 miles) per hour; then there are seven trains taking 96 minutes, speed 84·4 kilometres (52·4 miles) per hour; three taking 98 minutes, speed 82·7 kilometres (51·4 miles) per hour, and finally five taking 100 minutes, speed 81 kilometres (50·3 miles) per hour.

Jersey City-Philadelphia-Pittsburg (438 miles or 705 kilometres). — The best train on this line, known as the *Pennsylvania Special Express*, takes 8 hours 26 minutes on the outward and 8 hours 31 minutes on the return journey, the two stops amounting to 5 and 7 minutes respectively, the mean running speeds, stops deducted, being 84·4 and 83·9 kilometres (52·4 and 52·1 miles) per hour respectively. Thus this run can be compared with that of the *Empire State Express* (87·6 and 80·3 kilometres [54·4 and 49·9 miles] per hour). Another pair of trains has mean running speeds of 82·6 and 83·3 kilometres (51·3 and 51·8 miles) per hour. The sections Jersey City to Philadelphia (84 miles or 135 kilometres), Philadelphia to Harrisburg (105·3 miles or 169·5 kilometres), Harrisburg to Altoona, Altoona to Harrisburg (131·4 miles or 211·5 kilometres), Pittsburg to Harrisburg (248 miles or 400 kilometres) are covered at speeds of 97·6, 90, 84·6, 89 and 80 kilometres (60·6, 55·9, 52·6, 55·3 and 49·7 miles) per hour respectively; there are no intermediate stops on these sections. On the first section, Jersey City to Philadelphia, there are twelve other fast trains running at 90, 87·1, 85·3 and 84·4 kilometres (55·9, 54·1, 53 and 52·4 miles) per hour.

Pittsburg-Fort Wayne-Chicago. — This is the continuation of the last run; it is 468 miles or 753 kilometres long and the *Pennsylvania Special Express* covers it at mean running speeds of 82·6 and 83·5 kilometres (51·3 and 51·9 miles) per hour, stops deducted. Between Pittsburg and Fort Wayne (320 miles or 515 kilometres) the speed is 83·8 kilometres (52 miles) per hour; it reaches 95·2 kilometres (59·2 miles) per hour between

Englewood and Fort Wayne (141 miles or 227 kilometres), and on the return journey from Fort Wayne to Englewood it falls to 87·3 kilometres (54·2 miles) per hour. The same section is covered by the two next fastest trains in 192 and 206 minutes, that is at the appreciably lower speeds of 71 and 66·1 kilometres (44·1 and 41·1 miles) per hour.

Jersey City-Philadelphia-Baltimore-Washington (226 miles or 363 kilometres). — Two lines connect these four cities; we are here considering the Pennsylvania. The best outward run is in 4 hours 44 minutes (mean running speed, 78·9 kilometres [49 miles] per hour), and the best return run in 4 hours 50 minutes (77·8 kilometres [48·3 miles] per hour); between Baltimore and Wilmington (no stops, 68·6 miles or 110 kilometres) the mean speed is 82·5 kilometres (51·3 miles) per hour.

Jersey City-Philadelphia-Baltimore-Washington (228 miles or 367 kilometres). — This second route is called the *Royal Blue Line* and belongs to the Baltimore & Ohio Railroad; there are four trains which do the run in 4 hours 48 minutes, the mean running speeds, after deducting stops of 12 and 13 minutes, being 79·8 and 80 kilometres (49·6 and 49·7 miles) per hour. The fastest section is Wayne Junction to Elizabeth, 73·6 miles or 118·5 kilometres in 80 minutes (speed, 88·9 kilometres [55·2 miles] per hour). The inclusive speed of these four fast trains, between Jersey City and Washington, is 76·5 kilometres (47·5 miles) per hour. Next come two trains which take 5 hours 2 minutes and 5 hours 9 minutes, the inclusive speeds being 72·9 and 71·3 kilometres (45·3 and 44·3 miles) per hour. On the Fort Wayne-Elizabeth section, the two next best trains after the one mentioned, take 84 and 88 minutes, so that their speeds are 84·6 and 80·8 kilometres (52·6 and 50·2 miles) per hour.

Chicago-Detroit-Buffalo (519·5 miles or 836 kilometres). — The net running time is 11 hours 27 minutes in the one direction and 12 hours 29 minutes in the other, corresponding to speeds of 73 and 67 kilometres (45·4 and 41·6 miles) per hour. The fastest section is St. Thomas to Windsor, 111 miles or 179 kilometres; speeds, 91 and 89·5 kilometres (56·5 and 55·6 miles) per hour. The two next best trains only do 85·9 and 74·6 kilometres (53·4 and 46·4 miles) per hour. On another line, Chicago-Windsor-Buffalo, the mean speeds are 56 and 62·7 kilometres (34·8 and 39 miles) per hour. From Buffalo to Chicago via Cleveland, the maximum mean running speed is 70·2 kilometres (43·6 miles) per hour, the 525 miles or 845 kilometres of the Aire Line being covered in 12 hours 2 minutes net, and the 540 miles or 869 kilometres of the Michigan Line being covered in 12 hours 23 minutes net. On the Fort Wayne route, the 523 miles or 842 kilometres are covered at mean running speeds of 57·7 and 56·2 kilometres (35·9 and 34·9 miles) per hour.

Chicago-Omaha-San Francisco (2,279 miles or 3,669 kilometres). — The *Overland Limited Express* does the total distance in 71 hours 46 minutes and 68 hours, or stops deducted, in 68 hours 54 minutes and 65 hours 24 minutes, so that the true mean running speeds are 53·3 and 56·1 kilometres (33·1 and 34·9 miles) per hour. On the fastest section, Chicago-Omaha (493 miles of 794 kilometres) the mean running speeds are 62 and 66·2 kilometres (38·5 and 41·1 miles) per hour respectively.

Chicago-La Junta-San Francisco (2,576 miles or 4,147 kilometres). — The best train in this case is the *California Limited Express*, which takes 76 hours 55 minutes and 74 hours 45 minutes altogether, the mean running speeds being 55·6 and 57 kilometres (34·5 and 35·4 miles) per hour. On the fastest section, Chicago-La Junta, the mean running speeds are 63·2 and 67·2 kilometres (39·3 and 41·8 miles) per hour.

Philadelphia-Camden-Atlantic City. — Ferry-boats convey the passengers from Philadelphia to Camden, that is from one bank of the Delaware to the other. Two lines connect Camden and Atlantic City, the latter being a favourite seaside place, much frequented during the season. One, *via* Williamstown (length 55·5 miles or 89·3 kilometres), belongs to the Philadelphia & Reading, and every weekday there are five trains which do the distance in 50 minutes (107·2 kilometres [66·6 miles] per hour), two which do it in 54 minutes (99·2 kilometres [61·6 miles] per hour) and twelve other expresses which do it in 60 minutes and thus have a speed of 89·3 kilometres (55·5 miles) per hour. The other line, via Atco (length 59 miles or 95 kilometres), belongs to the Pennsylvania; one train takes 52 minutes (109·6 kilometres [68·1 miles] per hour), two take 54 minutes (105·6 kilometres [65·6 miles] per hour), two take 56 minutes (101·8 kilometres [63·3 miles] per hour), one takes 61 minutes (93·4 kilometres [58 miles] per hour) and two take 63 minutes (90·5 kilometres [56·2 miles] per hour). The fastest of these express trains leave Atlantic City for Philadelphia at 7·45, 8 and 8·15 a. m., and Philadelphia for Atlantic City at 3·40, 4, 4, 5 and 5 p. m.; they more especially cater for the rich bankers and merchants who reside either temporarily or permanently at the fashionable seaside place Atlantic City, and who have to spend, or wish to spend, the day in Philadelphia; and consequently the two competing lines try to beat or at least equal each other in the speed of their Atlantic City trains.

To sum up : the two competing lines between New York and Chicago, with distances of 963 miles or 1,550 kilometres and 907 miles or 1,460 kilometres respectively, which are done at inclusive speeds of 86·1 and 88·1 kilometres (53·5 and 54·7 miles) per hour, actually hold the world's record for long distance speeds. The best is the *Twentieth Century Express*, which leaves New York at 3·30 p. m. (eastern time) and arrives at Chicago at 8·30 a. m. (central time); it leaves Chicago at 2·30 p. m. and arrives at New York at 9·30 a. m. Thus it takes exactly 18 hours for the whole journey, all told, showing an inclusive speed of 86·1 kilometres (53·5 miles) per hour. The other is the *Pennsylvania Special Express;* passengers leave New York at 3·55 p. m. and arrive at Chicago at 8·55 a. m.; they leave Chicago at 2·45 p. m. and arrive at New York at 9·45 a. m. Thus the journey also takes 18 hours in either direction, but its inclusive speed is 81·1 kilometres (50·4 miles) per hour only. That difference of speed is due to the fact that the *Pennsylvania Special Express* has to climb and cross the Alleghany mountains, whereas the *Twentieth Century Express* runs mostly on the level (1). In order to enable these trains to keep to their rather limited schedule time, they have but few stops; the *Twentieth Century Express* has eight going west and six going east, of from 1 to 4 minutes each (total, 19 and 15 minutes respectively), and the *Pennsylvania Special Express,* six in each direction, of from 1 to 6 minutes each; moreover baggage is limited on the *Twentieth Century Express.* The charge for tickets is comparatively high; the ordinary express rate of 20 dollars (£4) is increased by an additional charge of 5 dollars (£1) for the sleeping car and a special rate of 10 dollars (£2), so that the whole 18 hours' journey costs 35 dollars (£7).

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(1) In the case of the *Pennsylvania Special Express* there is also the time lost in crossing the Hudson river. The train starts from Jersey City at 4·14 p. m.; passengers leave New York at 3·55 p. m. Similarly the train arrives at Jersey City at 9·25 p. m., and passengers reach New York at 9·45. The actual train times are thus 17 hours 39 minutes and 17 hours 40 minutes; the corresponding inclusive speed being 82·5 kilometres (51·3 miles) per hour. The distance from Jersey City to Chicago is 906 miles or 1,458 kilometres. (*Note by Editor.*)

Next must be mentioned the celebrated *Empire State Express* which the New York Central runs between New York and Buffalo (439·5 miles or 708 kilometres), which held the long distance record for speed until the 18 hour New York and Chicago trains were instituted. For many years now this train has been running from New York to Buffalo in 8 hours 15 minutes and from Buffalo to New York in 9 hours, the inclusive speeds being 85·8 kilometres (53·3 miles) per hour going west and 78·7 kilometres (48·9 miles) per hour going east. Consequently, it runs at a higher speed from New York to Buffalo than the *Pennsylvania Special Express,* but not when returning from Buffalo to New York. Moreover, the distance run is not quite half that covered by the *Pennsylvania Special Express.*

The three pairs of trains just mentioned are much superior to the other express trains running on the same lines; the figures given above show this. Thus between New York and Buffalo the best pair of trains show mean running speeds of 87·6 and 80·3 kilometres (54·4 and 49·9 miles) per hour, whereas the next pair only do 77·5 and 72·9 kilometres (48·2 and 45·3 miles) per hour. Similarly on the New York-Cleveland-Chicago line, the best pair in the two directions have mean running speeds of 87·3 and 87·7 kilometres (54·2 and 54·5 miles) per hour, whereas the next best pair only have speeds of 68 and 69·8 kilometres (42·3 and 43·4 miles) per hour. On the Jersey City-Pittsburg line, the best pair have running speeds of 84·4 and 83·9 kilometres (52·4 and 52·1 miles) per hour, and the next pair 82·6 and 83·3 kilometres (51·3 and 51·8 miles) per hour; but on the continuation, the Pittsburg-Chicago line, whereas the *Pennsylvania Special Express* has mean running speeds of 82·6 and 83·5 kilometres (51·3 and 51·9 miles) per hour, the next fastest trains have speeds of only 64·9 and 64·1 kilometres (40·3 and 39·8 miles) per hour.

Finally on the other United States lines, which so far have not been considered, the mean running speed of the best trains may be as low as 48 kilometres (29·8 miles) per hour, and never exceeds 73 kilometres (45·4 miles) per hour.

Conclusions. — The figures given above show that the highest speeds of American express trains are in many cases only made in one direction or by one train in either direction, whereas the next fastest trains on the same lines generally run at appreciably lower speeds. On the European railways on the other hand, more especially in France, Germany and England, there are generally, on the trunk lines, several express trains per day running at the same or very nearly the same speed, particularly on the long non-stopping runs. Taking it altogether, if we leave out of consideration the high speeds, of 100 to 109 kilometres (62 to 67·7 miles) per hour, of several trains which do the short distance Philadelphia-Atlantic City under the special conditions mentioned above, the speeds on the European trains are not only not inferior to the similar performances on the American railways, but are ahead of them as regards the comparatively larger number of quick trains running on the same lines; this may be considered as making up for the fact that the two pairs of trains running between New York and Chicago in 18 hours have inclusive speeds of 86·1 and 81·1 kilometres (53·5 and 50·4 miles) per hour over a much longer distance than any express trains in France, England or Germany.

II. — German railways.

During many years, the German speed record was held by the Berlin-Hamburg line with its D train No. 5, 1st and 2nd class, which ran, and still runs, from Hamburg to Wittenberge, 159·2 kilometres (98·9 miles), in 1 hour 51 minutes (leaves Hamburg 12·32 p. m., arrives Wittenberge 2·23 p. m.), the mean speed being 86·1 kilometres (53·5 miles) per hour. But this record was beaten October 1, 1906, when the time table for winter 1906-1907 came into force. The D express train No. 6, 1st and 2nd class, from Berlin to Halle, 161·7 kilometres (100·5 miles), was then accelerated; this train now takes 1 hour 50 minutes (leaves Berlin 8 a. m., arrives Halle 9·50 a. m.), so that its mean speed is 88·2 kilometres (54·8 miles) per hour. Nevertheless the Berlin-Halle line cannot yet be considered as absolutely the premier line for speed; if we consider the performances generally on the two lines, it must be admitted that the Berlin-Hamburg line is still ahead. Apart from the train which runs at the great speed of 88·2 kilometres (54·8 miles) per hour, the six next fastest express trains on the Berlin-Halle line all running without a stop, are materially slower; they all take 2 hours and so their speed is only 80·9 kilometres (50·3 miles) per hour. On the Berlin-Hamburg line on the other hand, there are five trains between Hamburg and Wittenberge taking 111, 112, 115, 115 and 117 minutes, their speeds being thus 86·1, 85·3, 83·1, 83·1 and 81·6 kilometres (53·5, 53, 51·6, 51·6 and 50·7 miles) per hour respectively; moreover between Berlin and Wittenberge, 126·8 kilometres (78·8 miles), there are also three other trains taking 91 minutes and two taking 93 minutes, the speeds thus being 83·6 and 81·8 kilometres (51·9 and 50·8 miles) per hour. So that taking it altogether the Berlin-Halle line has only one train with a speed exceeding 81 kilometres (50·3 miles) per hour, whereas there are five trains between Wittenberge and Hamburg with speeds of 81·6 to 86·1 kilometres (50·7 to 53·5 miles) per hour and also five between Berlin and Wittenberge with speeds of 81·8 to 83·6 kilometres (50·8 to 51·9 miles) per hour.

These two lines, Berlin-Hamburg and Berlin-Halle, as compared with all the other German lines, are distinguished by having the greatest number of long distance express trains running on them, at mean speeds of 80 kilometres (49·7 miles) per hour and upwards. Next comes the Berlin-Hanover-Hamm line; on this, between Hanover and Stendal, 150·6 kilometres (93·6 miles), there are three trains Nos. 3, 7 and 15 taking 107, 110 and 112 minutes, the speeds being 84·4, 82·1 and 80·7 kilometres (52·4, 51 and 50·1 miles) per hour respectively; then on the Oebisfelde-Stendal section (62·2 kilometres [38·6 miles]), there is train No. 13 which takes 46 minutes, speed 81·1 kilometres (50·4 miles) per hour; on the Oebisfelde-Lehrte section (72 kilometres [44.7 miles]), there is train No. 14, 54 minutes, speed 80 kilometres (49·7 miles) per hour; finally, from Bielefeld to Hamm (66·9 kilometres [41·6 miles]), there is train No. 22, 49 minutes, speed 81·9 kilometres (50·9 miles) per hour. Among other north German lines with express trains running at over 80 kilometres (49·7 miles) per hour, we may mention Berlin-Stettin, train No. 25, which goes from Angermünde to Stettin (63·8 kilometres [39·6 miles]) in 47 minutes, speed 81·4 kilometres (50·6 miles) per hour; and Berlin-Röderau-Dresden, D trains Nos. 56-55, first, second and third class. One of these trains runs from Berlin to Dresden-Neustadt, 188·7 kilometres (117·3 miles), in 2 hours 17 minutes, speed 82·6 kilometres (51·3 miles) per hour; the return train takes 2 hours 24 minutes and so only does 78·6 kilometres (48·8 miles) per hour.

A considerable number of the trains on the Baden State Railway were materially accelerated in the winter 1906-1907 time table. The following trains, running distances of at least 60 kilometres (37·3 miles) without stop, may be mentioned : Karlsruhe and Freiburg, 133·5 kilometres (83 miles), train No. 86, 96 minutes, 83·4 kilometres (51·8 miles) per hour; Freiburg to Oos, 102·9 kilometres (63·9 miles), train No. 85, 71 minutes, 87 kilometres (54 miles) per hour; Offenburg to Karlsruhe, 72·2 kilometres (44·9 miles), train No. 109, 54 minutes, 80·2 kilometres (49·8 miles) per hour; Freiburg to Offenburg, 62·8 kilometres (39 miles), the three trains Nos. 1, 9 and 109 taking 47, 46 and 43 minutes, with mean speeds of 80·2, 81·9 and 87·6 kilometres (49·8, 50·9 and 54·4 miles) per hour respectively; finally between Karlsruhe and Mannheim, 60·6 kilometres (37·7 miles), the two trains Nos. 86 and 85, taking 43 and 44 minutes, with mean speeds of 84·6 and 82·6 kilometres (52·6 and 51·3 miles) per hour respectively. The Baden State Railway with its high mean speeds of 87 and 87·6 kilometres (54 and 54·5 miles) per hour, kept up over runs of 102·9 and 62·8 kilometres (63·9 and 39 miles) respectively, thus beats the highest mean speed hithertho attained on the Berlin-Hamburg line, as stated above, by a train between Hamburg and Wittenberge; but this speed, of 86·1 kilometres (53·5 miles) per hour, is kept up on a run of 159·2 kilometres (98·9 miles).

The Alsace-Lorraine Railway has the following trains, running distances of at least 60 kilometres (37·3 miles) without stop, at mean speeds of at least 80 kilometres (49·7 miles) per hour : between Strasburg and Colmar, the four trains Nos. 6, 5, 163 and 179, taking 48 minutes, speed 81·8 kilometres (50·8 miles) per hour, and the three trains Nos. 180, 166 and 1, taking 49 minutes, speed 80·1 kilometres (49·8 miles) per hour.

As far as the author knows, there is no other German line on which a section at least 60 kilometres (37·3 miles) long is covered by express trains having mean speeds of at least 80 kilometres (49·7 miles) per hour. We may however mention, as a special case, the *ordinary train* No. 469 on the Saxon State Railway; this leaves Leipzig at 6 a. m., and arrives at Riesa at 6·51 a. m. The distance being 65·8 kilometres (40·9 miles), the mean inclusive speed is 77·4 kilometres (48·1 miles) ; there is probably no other ordinary passenger train in Germany which attains this speed.

MISCELLANEOUS INFORMATION

[656 .254]

1. — Wireless telegraphy in railway work.

It was recently stated in some of the daily papers, that the Prussian Military Railway and the Bavarian State Railway had adopted wireless telegraphy for communicating between stations and trains in motion.

Everyone familiar with the subject knows that this is to say the least a very premature statement.

The fact was that experiments, consisting in the exchange of ordinary messages, were made in conjunction with the Telefunken Company. Some of these messages were to trains in motion.

The public hence drew the erroneous conclusion that the present signals could be replaced by this new system and that there would be greater safety. The objection that it would be excessively costly to install a telegraph office on each train, was not even raised.

Messrs. Siemens and Halske, independently of this, made some experiments, in Germany, to utilize wireless telegraphy in order to inform the driver of a locomotive whether the road was clear. A coherer of simple construction was placed on each locomotive, together with a small electric motor or electromagnetic hammer.

As soon as waves were transmitted from a station to the train, the motor made a green signal appear, indicating that the line was clear. The disappearance of the signal meant " stop ". In the system tried, the mechanical connections of the ordinary signals operated contacts in the main circuit, contacts which had to be made when all was in order.

This arrangement worked very well in the trials made, except that there was some uncertainty in the call, due apparently to disturbances in the coherer, produced by the movements of the locomotive. With the coherers used, such failures occurred but seldom, but the apparatus remained delicate in spite of all the improvements made, and Messrs. Siemens and Halske therefore decided not to try to introduce its use in railway practice.

Similar experiments had already been made some time ago in Belgium by Messrs. César and Guarini. They were given up for analogous reasons. Considerable differences of potential between the two lines of rails, sufficiently serious to prevent the working of the apparatus, were occasionally observed; they were probably caused by an electric power station in the neighbourhood of the railway. The presence of a dynamo on the locomotive would also be a difficulty; now as electric lighting is becoming more and more generally used, more and more locomotives will be equipped with such a dynamo.

L. W.

[**621** .132.8]

2. — A German motor car.

Fig. 1, p. 561.

(*Railroad Gazette.*)

The Bavarian State Railroads have recently put in service the steam motor car illustrated herewith (fig. 1). The engine is carried on a bogie independent of the carriage frame. The principal peculiarity of the car is to be found in the cylinders and their arrangement. There is one cylinder upon each side, and in each of these there are two pistons working in opposite directions and driving the front and rear axles of the motor truck, respectively. The ostensible object of this method of working is to eliminate the perturbations due to the unbalanced thrust of the reciprocating parts. By this means, a four-cylinder engine is obtained, together with a virtual balance, as the cranks are on all four quarters, those on each side being set opposite each other, and at right angles to those on the other side. Owing to this arrangement and to the limited wheel-base, the connecting rods are very short, being only 26 $^1/_2$ inches long, with a piston stroke of 10 $^1/_4$ inches. This ratio of 2·58 to 1 between the connecting rod length and the stroke makes the angle at the point of maximum turning moment rather sharp, and when added to the fact that the pistons are moving in opposite directions and driving axles that are coupled together, it brings it about that there is a difference of 23° between the points of maximum crank effort of the two cranks that are driven from the same cylinder. Then, as the velocities and location of the two pistons are different for every point of the stroke except at the centers, it also follows that the point of cut-off differs for the two pistons and with it the amounts of power developed.

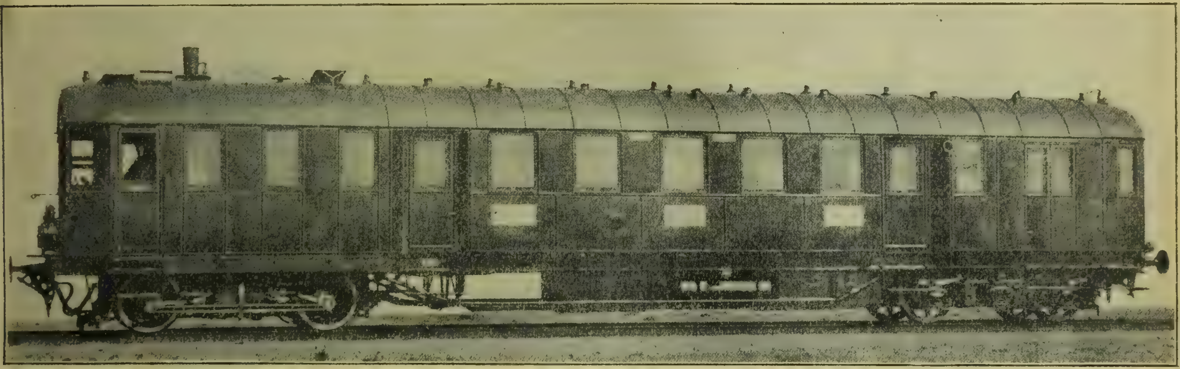

Fig. 1. — Steam motor car for the Bavarian State Railroads.

The Walschaerts valve gear driving piston valves is used, and this is operated by a single eccentric instead of the usual return crank. The lap and lead lever, which is usually driven by a connector from the cross-head arm, is, in this case, operated from a link attached directly to the center of the crosshead.

The connecting rods are made with forked ends, and take hold of the crankpin close to the wheels. Side rods are placed on pins outside the connecting rods, and it will be seen that, owing to the fact that the main crankpins approach and recede from each other, it is impossible to put the side rods on the main pins. They are, therefore, put on return cranks, whose centers are 90° from each of the main crankpins, thus dividing the distance between the two, which, in the matter of rotation is 180°. It is on one of these return cranks that the eccentric is placed.

The boiler is of the locomotive type and is fitted with a superheater. At the back end of the firebox, there is a bunker set above the door opening, from which the coal falls down upon the fire, the rate of feed being regulated by suitable traps, and peep holes are placed in the firedoors, through which the condition of the fire may be observed.

The car is worked by one man, the driver always remaining with the engine, no compartment being provided for him at the other end of the car. The car can seat 55 passengers and accommodate 35 standing in addition.

The tractive power is put down at 3,590 lb. and the hauling capacity is equivalent to moving two supplementary cars, each with the same seating capacity as the motor car itself, at a speed of 40 miles per hour. The engines are capable of developing 350 horsepower as a maximum, and driving the car at 47 miles per hour on a level. When running under these conditions, the coal consumption varies from 17 to 21 lb. per mile, that used being of the comparatively inferior character obtained in the north of Germany. A plan of the car would show it divided into four compartments. Two of these are for passengers, one for smokers and one for those who wish to avoid these conditions. Both are for third class travelers. A third compartment is for baggage and parcels, and the fourth, which is at the front, is for the boiler and engineman. The boiler is set at the back of the foot-plate, at the front of which are the usual levers and gauges used in the control of the machine. The principal dimensions of the car and engine are :

Engine.

Working pressure	235 lb.
Cylinders, diameter	8 inches.
— piston stroke	2 × 10 1/2 inches.
Driving wheels, diameter	39 inches.
Tractive power	3,590 lb.
Grate area	9·3 square feet.
Heating surface (inside) : Fire-box	37·3 — —
— — tubes	405·6 — —
— — total	442·9 — —
Superheater surface (fire contact)	74·8 — —
Aggregate surface	517·7 — —
Engine, weight, empty	35,840 lb.
— — loaded	40,320 lb.
Tank capacity	880 gallons.

Car.

Wheel, diameter	39 inches.
— base (motor bogie)	9 ft. 3/4 in.
— — (coach)	8 ft. 2 in.
Total wheel base	51 ft. 6 in.
Minimum curve radius	600 feet.
Total length of car	78 ft. 7 in.
Greatest breadth	9 ft. 6 in.
— height	14 ft. 9 in.

Motor car, weight, empty	100,800 lb.
— — — in working order	114,240 lb.
Trailing car, weight	88,480 lb.
Space for baggage	39 square feet.

[385 .15 (.45)]

3. — Notes on the Italian State Railways.

(*Zeitung des Vereins.*)

While the trade, manufacturing industry and agriculture of Italy are in the full vigour of prosperity, the means of traffic are insufficient and disorganized to the utmost degree. The State railways (comprising over 13,000 kilometres [8,000 miles] out of the total of about 16,000 [9,940 miles] which make up the entire system) are just those which are almost solely responsible for the lack of service, the *disservizio*, which is the new word coined to express the present shocking operation of the railways in Italy.

The remaining private railways, mostly of short mileage — the Sicilian Western, the two Sardinian railway systems and the Veneta company's lines — have found it possible, at least so far, to keep their service working regularly.

But it must not be deduced from this that intrinsically nationalisation is to blame for this state of affairs. It exists and must hold good, and there is no reasonable man in Italy who dreams of possibly returning to operation by private companies. It behoves rather to seek for the cause of the immense inferiority of the service in the extremely unfavourable circumstances under which the Government and the Parliament, goaded on by the agitation and the strike of the railway employees, undertook the nationalisation of the railways. In Prussia, in Switzerland, and now in Austria, this measure was undertaken with full cognizance of the difficulties and after long years of preparation; in Italy the case has been quite different.

Hurriedly and without truce, in the spring of 1905, an ill-considered bill was hustled through, providing that from the first of July, the operation of the railways should be retransferred to the State. Only six weeks prior to that date, Commander Riccardo Bianchi, then manager of the Sicilian railways, was appointed general manager, and he was entrusted with the duty of organising anew the management and operation. At the same time were made the district railway directorates, but the various managers could not be appointed and enter upon their duties until October and November. The district directorates were given very limited power and initiative, while at the same time throughout the political world of Italy, attempts were being made to centralize everything to the utmost degree possible. With this object in view, various central departments with their headquarters in Rome, were created and these are the real controlling authorities.

In order to do away with the misunderstanding that had long exsited between the staffs of the Mediterranean and Adriatic companies and of the Government railway inspectors' department (now abolished), an attempt was made to bring about a kind of amalgamation in the general management office by bringing together in each department officials from different sources. This attempt was inspired by generous ideas, but, it must be confessed, and those concerned themselves acknowledged the fact, it was an unfortunate experiment and the resulting confusion has only become greater. The lack of uniformity and the uncertainty of the orders given, the laziness, the opposition, and even the disobedience in executing the orders, were and are the consequences, and disagreements continue to arise wholesale.

Frequently, the occupations of the various officials have been altered in the most arbitrary manner; countless removals from all parts of the country to Rome and other places, in consequence of the new regime, have interfered with private interests. The sudden abolition of old and sound institutions, founded by the private companies, had unfortunate effects. Many officials, and especially those coming from the State inspection, had been promised high positions, and their enemies maintain that this was a recompense for the nationalisation so ardently desired and brought about by these officials. Consequently, there was a violation of the rights, real or imaginary, of the principal officials of the private companies. Doubtless time will heal these wounds, but more time will be needed to assuage all these feelings of resentment. Peace cannot come because further changes are continually happening and that justifiably because the too hasty organisation must be improved and nationalisation goes on unceasingly.

Meantime, the regulating power is deficient. One sees but few inspectors on the lines or at the stations, the station employees are casual and the service is abandoned almost entirely to the train staff. There is nothing astounding, therefore, in the fact that the trains — it is not a rare event — should be from one to five hours behind time and that they should be marshalled in such a way that the regularity and safety of the service and comfort on the journey are markedly lacking. The maintenance and cleanliness of the passenger cars are extremely deficient and the conveyance of express parcels is carried out with much carelessness. Full truck loads of express perishables and vegetables rot in the wagons and in the station warehouses, while luggage and parcels are lost, forgotten, despatched on wrong lines or separated from their way-bills.

Much has been done for the subordinate staff, considering the circumstances in Italy. The wages and extra allowances of the old employees have been increased by over 10 million lires (£400,000), while in 1902 there had already been granted an increase of 8 millions (£320,000), rising gradually to 24 millions (£960,000). But at the same time discipline has been relaxed; penalties have but seldom been exacted because there has been a fear of the all-powerful employees' unions, animated by socialistic idees. This is one of the causes of the bad service. Alongside these moral grounds for lack of order, a large part is played also by technical difficulties. The growth of traffic makes the poor supply of rolling stock more and more evident and also the poverty of station appliances. The lack of rollingstock is so marked that, at the port of Genoa for instance, instead of the normal numbers of 1,100 to 1,200 full truck loads *per diem* it has been possible to despatch only 500 and even, on certain days, only 298. The same is true of all the ports of Upper Italy: Venice, Leghorn, Savona, Spezzia. Coal and raw material is accumulating on the quays and on the lighters in vast quantities, while in the interior of the country many factories are obliged to restrict or entirely stop their output for want of fuel.

On the other hand, great pains were taken that there should be no lack of wagons for the vineyards. So many empty trucks were dispatched to Apulia and the other vine-growing districts that there occurred dangerous blocks in the traffic; to get over this, it was found necessary to stop for four days all consigning and loading. The grapes which deteriorate so rapidly had to remain in open baskets round the stations. The grape-gathering is over long ago; but the position of affairs in Upper Italy has not improved, for the empty trucks took a long time to get back to the ports, and owing to the scarcity of rolling stock experienced everywhere, it was found necessary to return to the owning managements, who were loud in their demands for the Austrian and French wagons retained at serious expense by the Italian government.

Though the government appeared weak in combating the moral failings mentioned above, it seemed all the more determined to abolish all technical imperfections. The Act of May 1905 placed of the disposal of the railway management 95 million lires (£3,800,000) to add to the rolling stock and to improve stations. There were voted a further 205 millions (£8,200,000) by the bill of April 19, 1906. The total credit for additions and new appliances amount to 300 million lires (£12 millions). It has been used in ordering 900 locomotives (a fairly large number from Germany), 1,500 passenger cars, 230 luggage vans and 19,200 goods wagons; a very considerable amount of these orders went abroad. All this rolling stock has to be delivered at latest in the summer of 1907. But little has been done to the stations; so far hardly any new works have been begun, those in hand dating from the time of the old operating companies. Large schemes have been prepared for enlarging and rearranging stations, laying a second track on long sections of single line. Safety appliances and electrification on important lines connecting Genoa and Savona with the Po plain country have been planned, and since then approved. Tenders for the works involved will soon be called. Meantime the cabinet has decided to apply to Parliament for a further sum of 400 million lires (£16 millions) for the railways. There is no doubt this further large sum which it is intended to spend at once, will be voted. The expenditure so far estimated amounted to 1,300 million lires (£52 millions), of which 1,000 million (£40 millions) was to complete and improve existing lines and 300 millions (£12 millions) for new lines. As 300 millions have already been spent and as a credit of 400 millions (£16 millions) was demanded as soon as ever the parliamentary session opened (November 22), about half the sum that was reckoned to be spent on railways in ten years will have been expended in the first two years.

As regards projected electrification, the intention is to deal with the following lines: the old Giovi line, from Pontedecimo to Busalla (section of the Genoa-Novi line), the line between Savona and Giuseppe (section of the Savona-Turin line) and the line between Turin and Bussoleno (first section of the Mont Cenis line, Italian side). As regards the Pontedecimo-Busalla line, tenders have already been sent in, and the most important electric works in the world applied. The tender of the Westinghouse Company of Pittsburg (U. S. A.) was accepted and to it the whole undertaking has been entrusted. The triphase current will be used, and power will be derived from steam motors. It is hoped that electric traction will considerably increase the carrying capacity of the line of which the steepest gradient is 35 per mil and the easiest 23. The result will be a marked easement, and a very essential one, for the port of Genoa.

It is understood that the railway management has also forwarded to the government the accounts for the year from July 1, 1905, to June 30, 1906. Among the figures so far known must be mentioned the gross receipts, amounting to over 385 million lires (£15,400,000) and the net proceeds, to be paid into the Treasury, attaining 67 millions

(£2,680,000). Though this is in excess of the preceding year (private operation), it is none the less true that the revenue that the State gets from its railways is very low and only represents a shade over 1 p. c. as the State has spent about 6 1/2 milliards (£260 millions) for its railways. Making all due allowances, it may be estimated that Italy's loss on working her own railways amounts to about 200 millions (£8 millions) *per annum*.

As for the new expenditure mentioned above, it is hoped that the interest and sinking fund service can be secured out of the annual surplus derived from the increased receipts arising from the heavy growth of traffic. The future will show how far this expectation is justified. The new passenger tariff was considered in a recent issue of the *Zeitung* (1).

It may be presumed that a national railway council will shortly be attached to the management headquarters in Rome and that district councils will be formed alongside the divisional directorates. The requisite preliminaries have already been carried out. As provided already in the bill of Mr. ex-minister Tedesco, these councils will consist of principle officials of the different departments and representatives of commerce, industry and agriculture. These will give their opinions, in an advisory way, upon tariffs, time-tables, traffic questions, etc.

While awaiting the final decision as to the administrative organisation of the State railways, the general manager has appointed a general traffic superintendent and a general construction supervisor. However, in order to conform to the present law, the new controllers are designated assistants to the general manager for the control of construction and operation. Much is looked for in Italy from this subdivision of labour, especially as the engineers appointed to these high positions have high reputations. The new traffic superintendent, especially, Commander Alzona, has already distinguished himself highly as traffic superintendent on the Adriatic railway and latterly, as superintendent of the important district of Milan, enjoyed the full confidence of the public. The only apprehension is lest the fear of arousing hostility from the staff may lead to refusing sufficient freedom of action to these superior officials, especially to the new and very energetic traffic superintendent, whereas there is need of the utmost energy if the present position of affairs is to be remedied. If seems as if it had now been decided to take radical measures in railway technical affairs.

[656 .283]

4. — The causes of railway collisions.

(*The Railway Age.*)

Although there are a few notable exceptions in newspapers which are better informed than others and which present well-considered comments on railway management in temperate language, the general attitude of the non-technical press towards railways today is one of extreme bitterness. A typical example of current newspaper editorials is that published in the *Chicago Daily News* on January 21, under the title « Slaughter on the Railroads. » The *News* says :

« Recent investigations of fatalities on railroads have revealed the most abominable violations of rules, or the complete absence of rational rules, for the protection of lives and property. It is, therefore, a justifiable inference that railroad passengers and trainmen are being butchered day by day because the management of the railroads to a greater or less degree is in the hands of ignorant, reckless, or otherwise incompetent persons.

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(1) Vide *Bulletin of the Railway Congress,* No. 4, April, 1907, p. 469.

« If men who are directly responsible for the safety of trains are worked to the point of exhaustion, they are rendered incompetent by fatigue. That it is not uncommon for accidents to happen from this cause has been proved by past inquiries into fatal wrecks. The La Follette bill, which prohibits railroad employes from working more than 16 hours without taking proper rest, has passed the senate and should be passed by the house without further delay. Steps should be taken by congress also to investigate thoroughly the causes of wrecks on railroads, and to provide such legislation as will compel the adoption of methods and appliances that will put a stop to preventable catastrophes of this sort.

« It is not necessary that the railroads of this country should pay dividends on their stock while they are making their train service safe. The question of expense to those corporations, should have little weight with congress in considering legislations that is deemed essential to put a stop to the continual sacrifice of human life by railroads which find it cheaper to kill than to refrain from killing. This matter must be taken up in earnest now by the lawmakers. In order that it shall be taken up in earnest, the people must cease to sumit meekly, like cattle in a shambles, to the butcheries that are going on day by day. They must demand that their indifferent representatives at Washington protect them from this peril. »

The insinuation that fatalities on railroads are caused by greed of the stockholders for dividends is gratuitous, and is in line with the comments of other journals which make no claims to fairness. The serious charges are that the management of the railways is in the hands of ignorant, reckless, or incompetent persons, and that the great number of wrecks occur because employes directly responsible are overworked. These charges are not warranted by the facts, and consequently the conclusions drawn as to the legislation, needed do not properly follow.

In the accompanying tables are shown the results of an analysis or the serious railway collisions which have been reported in the accident bulletins which are issued quarterly by the Interstate Commerce Commission. In compiling these data from the reports of the commission, collisions were considered because it is this class of accident which has caused so much discussion of block signal systems and excessive hours of work on the part of railroad employes. In each of the 20 quarterly accident bulletins, excepting No. 1, there has been given a list designated as « Class A » train accidents, which the commission definies as « those in which damage is reported at $10,000 or aver; notable cases in which passengers are killed, and those doing damage less than $10,000 and down to $2,000, wherever the circumstances or the cause may be of particular interest. » The collisions to which the accompanying tables refer, are those included in the « Class A » train accidents, and are for the period from October 1, 1901, to June 30, 1906, inclusive.

These reports show a total of 448 of what have been defined as serious collisions.

Summary showing causes of serious collisions reported in the Accident Bulletins of the Interstate Commerce Commission from October 1, 1901, to June 30, 1906, inclusive.

BULLETIN No.	Neglect of trainmen and enginemen.				When working excessive hours was coincident.				Other causes.				Totals.			
	Number of accidents.	Damage.	Killed.	Injured.	Number of accidents.	Damage.	Killed.	Injured.	Number of accidents.	Damage.	Killed.	Injured.	Number of accidents.	Damage.	Killed.	Injured.
2.	19	$254,326	64	213	...	...	...	...	8	$52,185	6	21	27	$306,511	70	234
3.	35	138,608	33	234	2	$8,500	3	7	4	13,049	7	14	41	160,247	43	255
4.	22	208,792	27	181	2	4,600	2	1	2	15,200	1	5	26	228,592	30	187
5.	12	143,803	37	127	...	...	...	...	3	73,648	9	34	15	217,451	46	161
6.	17	168,359	49	116	3	8,894	2	8	6	91,131	5	55	26	268,384	56	179
7.	20	176,129	67	209	2	2,785	1	...	4	129,127	16	42	26	308,041	84	251
8.	19	250,761	42	202	...	...	...	...	10	169,194	10	98	29	419,955	52	300
9.	14	178,109	56	265	...	...	...	...	5	46,375	6	31	19	221,484	62	296
10.	18	215,296	125	266	1	5,100	...	4	2	16,105	1	18	21	236,501	126	288
11.	12	157,467	34	121	1	5,900	1	...	7	58,110	3	36	20	221,477	38	157
12.	12	108,075	10	190	...	...	...	...	6	54,375	5	16	18	162,450	15	206
13.	15	207,072	97	440	2	7,220	...	26	7	86,067	45	135	24	300,359	142	601
14.	13	149,250	44	184	3	39,888	3	17	8	160,722	22	85	24	349,860	69	286
15.	14	152,428	25	218	4	32,251	7	12	6	28,333	3	39	24	213,012	35	269
16.	14	167,093	52	187	...	...	...	...	...	24,800	2	12	17	191,893	54	199
17.	13	149,319	45	380	...	...	...	...	6	56,448	7	36	19	205,797	52	416
18.	19	218,028	55	164	2	13,350	...	3	6	71,213	6	76	27	302,591	61	243
19.	21	234,985	30	229	1	5,440	...	3	9	118,174	49	164	31	358,599	79	396
20.	8	65,945	12	66	1	2,187	1	4	5	32,879	2	117	14	101,011	15	187
Totals . . .	317	$3,343,965	904	3,992	21	$136,115	20	85	107	$1,297,135	205	1,034	448	$4,777,215	1,129	5,111
Per cent. . .	70·7	70·0	80·1	78·1	5.4	2·9	1·8	1·7	23·9	27·1	18·1	20·2	100·0	100·0	100·0	100·0

Causes of serious collisions reported in the Accident Bulletins of the Interstate Commerce Commission October 1, 1901, to June 30, 1906, inclusive.

—	COLLISIONS.		PERSONS KILLED.		PERSONS INJURED.		DAMAGE TO ENGINES, CARS AND ROADWAY.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Amount.	Per cent.
A. Collisions in automatic block signal systems:								
Because of failure of system . . .	1	0·2	1	0·1	4	0·1	$3,678	0·1
— of disregarding signals . .	17	3·8	63	5·6	484	9·5	176,889	3·7
Totals. . .	18	4·0	64	5·7	488	9·5	180,567	3·8
B. Collisions in non-automatic block signal systems:								
Because of failure of system . . .	2	0·4	1	0·1	8	0·2	12,300	0·3
— of error of signalmen. . .	(1) 24·5	5·5	48·5	4·3	254·5	5·0	222,541	4·7
— of disregarding signals, etc.	(1) 4·5	1·0	4·5	0·4	20·5	0·4	26,748	0·6
Totals. . .	31	6·9	54	4·8	283	5·6	261,589	5·6
C. Collisions as to which automatic block signals would have given warning. . .	331	73·9	872	77·2	3,847	75·3	3,686,285	77·0
D. Collisions as to which automatic block signals would have afforded no additional protection	68	15·2	139	12·3	493	9·6	648,774	13·6
Grand totals. . .	448	100·0	1,129	100·0	5,111	100·0	$4,777,215	100·0

(1) Fractions caused by divided responsibility in one case.

From the brief statements given in the bulletins as to the cause of each of these collisions, they have been divided into three classes :

1° Those collisions which were caused by the negligence of the trainmen or enginemen. This class comprises 317 accidents, involving damage to engines, cars and roadway of $3,343,965 and resulting in the death of 904 persons and the injury of 3,992 others. Stated in percentages, the collisions due to negligence of trainmen and enginemen comprised 70·7 per cent of the number of accidents and resulted in 70 per cent of the money damage, 80·1 per cent of the deaths and 78·1 per cent of the personal injuries;

2° As a separate class, have been taken those accidents wherein the Interstate Commerce Commission reports show that the man or men charged with responsibility for the accident had been on duty more than 16 hours preceding the occurrence, and these are classed by themselves under the head « When Working Excessive Hours Was Coincident. » This definition of excessive hours as being more than 16, is assumed not because we believe that 16 hours is the limit beyond which a railway employe may not work without endangering safety of trains, but because it is the limit named in the bill now pending in congress. It should not be overlooked that in these « excessive hours » cases, the facts of negligence and of the men having worked more than 16 hours are only coincident, and not necessarily effect and cause. The total number of these « excessive hours » collisions was 24, resulting in property loss of $136,115, the death of 20 persons and the injury of 85 others. In percentages of the total number of serious collisions covered by the table, the number of accidents in this class was 5·4 per cent, the property damage 2·9 per cent, the number of deaths 1·8 per cent, and the number of personal injuries 1·7 per cent of the respective totals;

3° Serious collisions due to causes other than negligence of trainmen and enginemen and excessive hours. These accidents include those cases wherein the negligence was that of dispatchers and signal operators. The number of accidents so classified was 107, entailing property loss of $1,297,135 and resulting in the death of 205 persons and injury of 1,034. The number of accidents from other causes was 23·9 per cent, property damage 27·1 per cent, number killed 18·1 per cent, and the number injured 20·2 per cent of the respective totals.

The total damage because of the 448 collisions was reported as $4,777,215, the total number of persons killed as 1,129, and the total number injured as 5,111. It should be remembered that « damage » as used in the accompanying tables means damage to engines, cars and roadway and does not include expenditures by the claim and legal departments of the railways in connection with these fatalities and injuries.

The most striking point brought out in this analysis, is the extremely small number of accidents wherein it has been shown that the employes concerned have been working an excessive number of hours, and the even smaller relative proportion of the number of fatalities and number of personal injuries which resulted from these few accidents.

The preceding statement presents the totals of a classification based upon the negligence of employes. The 448 collisions have also been classified in another way to show the efficiency of signal systems. These classes have been taken as follows :

A. *Collisions in automatic block signal systems.* -- These are further subdivided into :

1° Those caused by failure of the system; 2° those caused by employes disregarding the signals. There are 18 of the collisions which come under class A, but only one or 0·2 per cent of the total number was the fault of the system. Negligence was responsible for 17 accidents, or 3·8 per cent of the total of serious collisions.

B. *Collisions in non-automatic block signal systems.* — These collisions been divided into three subclasses : 1° Those caused by the failure of the system; 2° those caused by errors of the signalmen; 3° those caused by disregarding signals. In the case of one accident, it appeared that responsibility was divided and it has been listed as a fraction in both subdivisions 2 and 3. The total of the collisions coming under class B was 31, and here, as in class A, the important fact is that but two collisions, or less than 0·4 per cent of the total number under consideration, were caused by failure of the signal system. In both class A and class B, reference to the table shows that over 94 per cent of the accidents and over 98 per cent of the losses of life were caused by negligence of employes and not by inefficient signal systems.

C. *Collisions as to which automatic block signals would have given warning.* — This class includes 331 of the serious collisions, this number being 73·9 per cent of the total, and shows a strong argument in favor of the adoption of automatic block signals, but even had warning been given in the 331 cases, we have no reason to presume all of these accidents would have been prevented, inasmuch as 94 per cent of the collisions under A and B are seen to have been due to errors of signalmen and disregard of signals by trainmen and enginemen.

D. — The residue of the serious collisions which the Interstate Commerce Commission has reported, are those wherein automatic block signals would have afforded no additional protection. These are 68 in number and constitute 15·2 of the total. The number of persons killed and injured and the property damage is in each case somewhat less than 15·2 per cent of the respective total.

The lesson to be drawn from the analysis of these official reports is one which railway men cannot do too much to bring to the consideration of the public and of the daily press, through which the public gets its information. What is needed is a proper appreciation of where the blame for the slaughter on the railroads really lies. When the public learns that everything inimical to discipline in the great army of railway employese adds just that much more to the danger the public incurs in traveling, railway employes adds just that much more to the danger the public incurs in travelling, then we may hope that the railway managements will receive from the public that support which they properly deserve.

[385. (06.111]

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

LIST OF THE QUESTIONS

for discussion at the eighth session of the Railway Congress (Bern, 1910) with indication of the names of the reporters.

SECTION I. — WAY AND WORKS.

I. — Rail-joints.

A. Reduction in the number of joints by increasing the length of the rails. Maximum length to be adopted for ordinary track rails. The welding of rail-joints.

B. The strengthening of rail-joints.

Reporters :

France, Belgium, Italy, Spain and Portugal. — M^r^ CHATEAU, ingénieur des ponts et chaussées, ingénieur du matériel fixe de la voie et des travaux de la Compagnie des chemins de fer de l'Ouest français; rue de Londres, 49, Paris (VIII^e^).

Austria-Hungary, Rumania, Bulgaria, Servia, Turkey and Egypt. — M^r^ KRAMER (Frederic), ingénieur principal au service de la construction et de l'entretien des chemins de fer de l'État hongrois; Lipot-Körut, 1, Budapest.

Countries using the English language. — M^r^ ROSS (Alexander), engineer in chief, Great Northern Railway; King's Cross Station, London N.

Other Countries. — M^r^ FRAHM, Regierungs- und Baurat, Mitglied der Königlich preussischen Eisenbahndirektion in Berlin; Mommsenstrasse 11^I^, Gr. Lichterfelde-West (Berlin).

II. — Strengthening the track and the bridges with a view to increasing the speed of trains.

A. Increasing strength of road on account of increased weight of locomotives and speed of trains. Means for increasing the speed on curves without increasing the superelevation of the outer rail to a corresponding extent. Economy of maintenance to be realized from the use of a stiffer track. Cross-section and quality of the rail. The spacing of wooden sleepers and their seats. Substitution of other materials for wood in making sleepers.

B. The suitable strengthening of existing metal bridges proportionately to the increase in the weight of the locomotives and in the speed of the trains.

Reporters :

Austria-Hungary, Bulgaria, Rumania, Servia and Turkey. — Litt. A. — Mr Rosche (Hermann), conseiller de régence, directeur général du chemin de fer Aussig-Teplitz; Teplitz (Bohemia).

America. — Litt. A. — Mr Byers (M. L.), chief engineer maintenance of way, Missouri Pacific Railway; St. Louis (Mo.).

Spain, Portugal and other countries using the same language. — Litt. B. — Mr Coderch (Rafael), ingénieur en chef de la voie et des travaux du réseau catalan de la Compagnie du chemin de fer de Madrid à Saragosse et à Alicante; Marquesa, 2 bis pral, Barcelona.

Austria-Hungary. — Litt. B. — Mr Maurer (Maurice), inspecteur principal des chemins de fer de l'État hongrois; Budapest.

Bulgaria, Rumania, Servia and Turkey. — Litt. B. — Mr Zahariade (P. A.), ingénieur en chef, chef du service des ponts aux chemins de fer de l'État roumain; Str. Manea Brutaru, 12-14, Bucharest.

France and Italy. — Litt. B. — Mr Randich (E.), sous-chef de service à la Direction générale des chemins de fer de l'État italien, service central XI°; Palazzo Pizzardi, Bologna.

Holland and Belgium. — Litt. B. — Mr Schroeder van der Kolk (J.), ingénieur de l'État pour la surveillance des chemins de fer dans les Pays-Bas; Badhuisweg, 7a, The Hague.

Russia. — Litt. B. — Mr Belelubsky (N.), conseiller d'État actuel de Russie, professeur honoraire; Serpouchovskaia, 4, St-Petersburg.

Great Britain. — Litt. A. and B. — Mr Jacomb-Hood (J. W.), engineer, London & South Western Railway; Waterloo Station, London. S. E.

Other Countries. — Litt. A. — Mr Frahm, Regierungs- und Baurat, Mitglied der Königlich preussischen Eisenbahndirektion; Berlin.

Other Countries. — Litt. B. — Mr Labes, Regierungs- und Baurat, Mitglied der Königlich preussischen Eisenbahndirektion; Berlin.

III. — Junctions and swing-bridges. Elimination of slacking.

Arrangement of the road appliances for passing at high speed over switches and swing bridges.

Reporters :

France, Italy, Spain and Portugal. — Mr Tettelin, ingénieur principal des études, matériel des voies et bâtiments du chemin de fer du Nord français; rue de Dunkerque, 18, Paris, and Mr Cossmann (M.,) ingénieur, chef des services techniques de l'exploitation du chemin de fer du Nord français; rue de Maubeuge, 95, Paris (Xe).

Great Britain. — X...

America. — Mr Besler (W. G.), vice-president and general manager, Central Railroad of New Jersey; Liberty Street, 143, New York City.

Other Countries. — Mr Motte (Lucien), inspecteur général à la direction des voies et travaux des chemins de fer de l'État belge; rue de Louvain, 11, Brussels.

IV. — Long railway tunnels. Construction, ventilation and operation.

Methods used in constructing, ventilating and operating long railway tunnels.

Reporters :

France. — Mr Sartiaux (Félix), ingénieur attaché au service central de l'exploitation du chemin de fer du Nord français; rue de Dunkerque, 18, Paris (Xe).

Other Countries. — Mr Hennings (F.), ingénieur en chef, professeur à l'École polytechnique fédérale de Zurich; Utoquai, 29, Zurich (1).

SECTION II. — LOCOMOTIVES AND ROLLING STOCK.

V (I of Section 2). — The use of steel. Special steels.

A. Use of steel in the construction of locomotives and rolling stock; freight and passenger wagons entirely of steel.

B. Use of special steel of high resistance in the making of the various parts of locomotives and rolling stock (tires, axles, springs, couplers, boilers, etc.).

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(1) Appointed reporter on the proposal of the *Chemins de fer fédéraux*.

Reporters :

America. — Litt. A. — Mr Crawford (D. F.), general superintendent of motive power, Pennsylvania Lines West of Pittsburgh; Pittsburgh (Pa.).

All Countries except America. — Litt. A. — Mr Szlabey (Ernest), inspecteur principal, sous-directeur au service du matériel et de la traction des chemins de fer de l'État hongrois; Andrassynt, 75, Budapest.

America. — Litt. B. — Mr Ettinger (R. L.), consulting mechanical engineer, Southern Railway; Washington D. C.

Countries belonging to the « Verein Deutscher Eisenbahn-Verwaltungen ». — Litt. B. — Mr Hönigsberg (Otto), ingénieur à la Société des chemins de fer du Sud de l'Autriche; Südbahnhof, Vienna.

Great Britain. — Litt. B. — X...

Other Countries. — Litt. B. — Mr Le Blant, ingénieur du service des réceptions et atelier des essais mécaniques de la Compagnie des chemins de fer de l'Est français; rue Lafayette, 168, Paris (Xe).

VI (II of Section 2). — Improvements in locomotive boilers.

A. Boilers with smoke tubes; precautions in constructing and maintaining tubes and tube-plates.

B. Boilers with water tubes. Steam superheaters and valve gear for superheated steam. Feed water heaters.

C. Damages to boilers, blisters, cracks and corrosions. Means employed for preventing these damages. Purification of the water and disincrustants or antifouling compounds.

Reporters :

Russia. — Litt. A. — Mr Antochine (N.), ingénieur des voies de communication, membre du conseil technique du ministère des voies de communication de Russie; Fontanka, 117, St-Petersburg.

Austria-Hungary, Rumania, Bulgaria, Servia and Turkey. — Litt. B. — Mr Gerstner (Franz), conseiller du Gouvernement, inspecteur général et chef du service du matériel et de la traction de la Société privilégiée austro-hongroise des chemins de fer de l'État; Schwarzenbergplatz, 3, Vienna.

Russia. — Litt. B. — Mr Noltein (G.), ingénieur, administrateur de la Société du chemin de fer de Moscou-Kazane; Moscow.

France, Belgium, Italy, Spain and Portugal. — Litt. B. — Mr Dassesse (C.), ingénieur principal à la direction de la traction et du matériel des chemins de fer de l'État belge; rue de Louvain, 13, Brussels.

Austria-Hungary, Rumania, Bulgaria, Servia and Turkey. — Litt. C. — Mr Müller (Jean), inspecteur principal au service du matériel et de la traction des chemins de fer de l'État hongrois; Budapest.

France, Belgium, Italy, Spain and Portugal. — Litt. C. — Mr Nadal, ingénieur des mines, ingénieur en chef adjoint à l'ingénieur en chef du matériel et de la traction des chemins de fer de l'État français; boulevard Raspail, 136, Paris (VIe).

America. — Litt. C. — Mr Dudley (C. B.), chemist, Pennsylvania Railroad; Altoona (Pa.).

Great Britain. — Litt. A, B and C. — Mr Fowler (H.), works manager, Midland Railway, and Mr Archbutt (L.), chemist, Midland Railway; Derby.

Other Countries. — Litt. A, B and C. — Mr Steinbiss, Ober- und geheimer Baurat, Mitglied der Königlich preussischen Eisenbahndirektion in Kattowitz, member of the Congress permanent Commission; Kattowitz.

VII (**III of Section 2**). — **Steam locomotives for very high speeds.**

Steam locomotives for obtaining regulation speeds exceeding 60 miles per hour.

Reporters:

America. — Mr Garstang (William), superintendent of motive power, Cleveland, Cincinnati, Chicago & St. Louis Railway; Indianapolis (Indiana).

Other Countries. — Mr Courtin, Grossherzoglicher Baurat, Mitglied der Grossherzoglichen Generaldirektion der Badischen Staatseisenbahnen; Karlsruhe.

VIII (**IV of Section 2**). — **Electric traction.**

Electric traction on large railroads. Continuous current. Alternating current (monophase or polyphase). Comparative net cost.

Reporters:

Germany. — Professor Dr Gleichmann, Königlicher Obermaschineninspektor bei den Königlich Bayerischen Staatseisenbahnen, member of the Congress permanent Commission; Munich.

America. — Mr Gibbs (Geo.), chief engineer of electric traction, Long Island Railroad; Bridge Street, 10, New York (City).

Other Countries. — Dr Wyssling, professeur à l'École polytechnique fédérale de Zurich; Waedensweil (canton de Zurich) (1).

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(1) Appointed reporter on the proposal of the *Chemins de fer fédéraux*.

SECTION III. — WORKING.

IX (I of Section 3). — Large stations.

A. LARGE PASSENGER STATIONS. — Best arrangement of tracks so as to increase their working capacity and ensure safety in shunting operations. Improved mechanical appliances for the conveyance of luggage, etc.

B. LARGE GOODS STATIONS. — 1° Arrangements of tracks : *a*) to allow the continuity of movement of vehicles which require shunting and which are separate from the time the train bringing them has arrived until the train taking them away is being made up; *b*) to prevent such movement from being interfered with by the arrival or departure of trains; *c*) to stop without shock such separate vehicles at the end of the successive movements required; *d*) to start them off again.

2° New appliances for handling goods.

Reporters :

America. — Litt. A. — Mr McCHESNEY (W. S.) Jr., president and general manager, Terminal Railroad Association of St. Louis; St. Louis (Missouri).

America. — Litt. B. — Mr JAGGARD (H. A.), superintendent Pennsylvania Railroad; Elmira (N. Y.).

Russia, Austria-Hungary, Rumania, Bulgaria, Servia and Turkey. — Litt. A and B. — Mr KAIN (A.), inspecteur aux chemins de fer de l'État hongrois; Terez-Körut, 56, Budapest.

Other Countries. — Litt. A and B. — Mr JULLIEN, ingénieur des ponts et chaussées, ingénieur chef des services techniques de la voie de la Compagnie du chemin de fer d'Orléans, and Mr LEVERVE, ingénieur des ponts et chaussées, attaché au service central de l'exploitation de la Compagnie du chemin de fer d'Orléans; place Valhubert, 1, Paris (XIIIe).

X (II of Section 3). — Operation of switches and signals.

A. Improved centralized installations for operating switches and signals. The use of water, of compressed air, of electricity, for working the transmissions. Electric interlocking. Route levers.

B. Arrangements adopted to prevent switches taken from the facing or the trailing side from changing their position before the whole train has passed.

C. Use of diagrams to facilitate the consideration of the full utilization of tracks along passenger platforms and the modifications to be made, in cases of urgency, in the way these tracks are used.

Reporters :

Holland. — Mr Dufour (L. H. N.), ingénieur en service général à la Compagnie pour l'exploitation des chemins de fer de l'État néerlandais; Utrecht.

Countries belonging to the « Verein Deutscher Eisenbahn-Verwaltungen ». — Professor Dr. Ulbricht, geheimer Baurat, vortragender Rat im Königlich Sächsischen Finanzministerium, member of the Congress permanent Commission; Dresden.

America. — Mr Carter (E. C.), chief engineer, Chicago & Northwestern Railway; Chicago (Illinois).

Other Countries. — Mr Weissenbruch (L.), ingénieur en chef, directeur du service des appareils de sécurité des chemins de fer de l'État belge, and Mr Verdeyen, ingénieur, adjoint au directeur du service des appareils de sécurité des chemins de fer de l'État belge; rue Belliard, 76, Brussels.

XI (III of Section 3). — Passenger tickets.

Different types of passenger tickets. Systems enabling the number of blank tickets to be reduced. Simplified tickets for stopping places. Apparatus for printing tickets (and checking them) as and when required.

Reporter :

All Countries. — Direktor Dr von Oesterlen, vorstand der Verwaltungsabteilung der Generaldirektion der Königlich Württembergischen Staatseisenbahnen, member of the Congress permanent Commission; Stuttgart.

XII (IV of Section 3). — 2nd and 3rd sections jointly). Motor vehicles.

The use and cost of motor vehicles or self moving cars.

Reporters :

Great Britain. — Mr Riches (T. Hurry), locomotive, carriage and wagon superintendent, Taff Vale Railway; Penylan Road, 102, Roath Park, Cardiff.

America. — Mr Clark (C. P.), vice-president and general manager, Buffalo & Susquehanna Railroad; Ellicott Square, 962, Buffalo (N. Y.).

Other Countries. — Mr Greppi (L.), inspecteur en chef des chemins de fer de l'État italien, service central matériel et traction; via Boncompagni, 21, Rome.

SECTION IV. — GENERAL.

XIII (**I of Section 4**). — **Railways and waterways.**

The investigation of the influence of waterways considered as feeders and as competitors, on railways.

Reporters :

Great Britain. — Mr Jebb (G. R.), chief engineer of the Shropshire Union Railways and Canal Company and of the Birmingham Canal Navigations; New Street Station, Birmingham.

America. — Mr Wilgus (W. J.), vice-president, New York Central & Hudson River Railroad; New York (City).

Other Countries. — Mr Colson (C.), ingénieur en chef des ponts et chaussées, conseiller d'État de France, member of the Congress permanent Commission; boulevard Saint-Germain, 139, Paris.

XIV (**II of Section 4**). — **Statistics.**

A. **Principles of statistics of railways in operation.**

B. **Uniform classification of working expenses.**

Reporters :

Great Britain. — Mr Acworth (W. M.); the Albany Piccadilly, London W.

America. — Mr Knibloe (F. K.), general agent, Buffalo Creek Railroad; Buffalo (N. Y.).

Other Countries. — Mr Hodeige (A.), inspecteur général à la direction de l'exploitation des chemins de fer de l'État belge; rue de Louvain, 13, Brussels.

XV (**III of Section 4**). — **Motor car services.**

Porterage, cartage and connecting services by motor car.

Reporter :

All Countries. — Mr Inglis (J. C.), general manager, Great Western Railway; Paddington Station, London W.

XVI (**IV of Section 4**). — **Perishable goods.**

Suitable measures for developing the traffic in perishables : packing, refrigerator vans, appliances for keeping temperature constant, etc.

Reporters :

Countries using the English language. — Mr Culp (J. M.), vice-president, Southern Railway; Washington (D. C.).

Other Countries. — Mr Bloch, ingénieur en chef, adjoint au chef de l'exploitation de la Compagnie du chemin de fer d'Orléans; place Valhubert, 1, Paris (XIIIe).

SECTION V. — LIGHT RAILWAYS.

XVII (I of Section 5). — (3rd AND 5th SECTIONS JOINTLY). **Lines belonging to main railways but having not much traffic.**

Simplification in operating lines belonging to main railways but having not much traffic.

Reporter :

All Countries. — Mr Quarré, ingénieur en chef, adjoint au chef de l'exploitation de la Compagnie des chemins de fer du Midi français; boulevard Haussmann, 54, Paris (IXe).

XVIII (II of Section 5). — **The working of light railways.**

Examination of the results of the different systems used in operating light railways (leasing, operating jointly with corresponding main railway, working by concessionary himself, with or without guarantee or subvention from the authorities granting the concession).

Reporter :

All Countries. — Mr Plocq, ingénieur chef de l'exploitation des réseaux de la Somme et du Nord de la Société générale des chemins de fer économiques français; rue d'Amiens, 25, Arras.

XIX (III of Section 5). — **Locomotives and rolling stock of narrow-gauge light railways.**

A. Types of the latest locomotives used on narrow-gauge light railways, with due consideration to the profile of the line and the class of traffic.

Is it advisable : 1° to protect the wheels and the moving parts by a metal cover; 2° to have a foot-plate at each end of the locomotive? What regulations are there on the subject?

B. What are the latest types of carriages and wagons used on narrow-gauge light railways?

Reporter :

All Countries. — Mr JESSER (Moriz), inspecteur aux chemins de fer du Sud de l'Autriche; Südbahnhof, Vienna.

XX (IV of Section 5). — Transhipment.

Examination of the different systems adopted for the exchange of goods between lines of different gauges (transhipment at the same level, sunk or raised tracks, trucks for taking cars of another gauge, tracks with three or four lines of rails, etc.).

Reporter :

All Countries. — Mr DE BURLET, directeur général de la Société nationale belge des chemins de fer vicinaux, member of the Congress permanent Commission; rue de la Science, 14, Brussels.

[385. (09.2]

OBITUARY

Jean ADADOUROV,

Civil engineer,
President of the Riazan-Ouralsk secondary railways,
Member of the Permanent Commission of the International Railway Congress Association,
Delegate to the Brussels (1885), St. Petersburg (1892), London 1895), Paris (1900),
and Washington (1905) sessions.

On last New Year's day, there passed away one of the most eminent and most gifted among Russian railway men, Ivan Eugraphevitch Adadourov, who enjoyed the sympathy of all his colleagues and of all those who knew him.

For nearly half a century (since 1859), Ivan Eugraphevitch Adadourov had made railways his life-work. After having, for two years, on his joining the service of the Riazan-Koslov railway (in 1867), filled the position of divisional inspector, he was appointed general manager of that railway. Young and full of ability, he exhibited in this lofty position exceptional capacity which caused him to be appointed a member of the board by the shareholders of this company and for fifteen years he was its leading figure. When the undertaking was amalgamated with the Riazan-Ouralsk railway, he was re-elected chairman of the board and remained so till his death. While he belonged to the Riazan-Koslov railway, he was also a member of the board of the Koursk-Kiev railway. It should here be added that the time during which he belonged to the Administration of ways and communications was the period when the Russian railways were being organized, an organization that was to be brought about without there being any example that could be followed, for the organizations which were then taking place beyond the boundaries of Russia, could afford neither rule nor indication because they in no way corresponded with the peculiar circumstances encountered in that country.

It was within this period that occurred the foundation in Russia of the railway associations in which Mr. Adadourov personally played so active a part.

The first conference of railway managers was summoned by imperial edict in June 1868 to meet in the town of Koslov, and the Minister of ways and communications was present at it. Its object was to create through services for goods traffic. Mr. Ivan Adadourov was elected president, a position to which he was re-elected at all the subsequent conferences of the second group as long as this institution lasted, until they were absorbed by the far-reaching association which now embraces all Russia. Between 1868 and 1893, there were ninety-four meetings of the second

Jean Adadourov.

group over which Mr. Adadourov presided without a break, and he there exhibited his capacity, not only as an unrivalled collaborator, but also as the author of a host of reasonable schemes and the originator of a large number of useful measures for the improvement both of the through traffic services and of many other branches of operation. Thus Mr. Adadourov worked out without assistance, in 1880, the whole highly important subject of the proper system of tariffs to be adopted; the scheme he propounded of a convention to settle a far-reaching system of tariffs applicable to the whole country, was approved by the 15th general conference of railway managers. It was on his initiative that were started in Russia the through rates for the traffic between the great marts and ports; the conditions under which goods traffic was carried were simplified to allow of the rates being arranged reasonably; to introduce these measures he founded, on behalf of the railways belonging to the second group, a special committee. Thanks to Mr. Adadourov, there was enacted between the managements of this group, a simplified system of settling the respective accounts of these railways and a special fund was formed for this purpose. It would be hard to enumerate all the extremely various schemes and proposals devised by Mr. Adadourov during his career that extended over nigh half a century. Every advantageous or profitable undertaking was sure to win his active and courageous support.

With quite peculiar devotion and indefatigable energy, he took a prominent part also in the technical consultative societies, founded in 1879 as technical consultative conferences, for the investigation and study of technical subjects appertaining to the building and working of railways. Without the moral and financial support of Mr. Adadourov, this institution, which had great difficulties at the start, would never have flourished as it does at present.

The first consultative conference of the way and works department's engineers was called together by Adadourov in 1881; in May 1882, he summoned the conference of traffic inspectors; at the same time, thanks to his efforts and good offices, the general conference approved the by-laws of the technical consultative conferences. The general conference chose Mr. Adadourov as its delegate to inspect these technical conferences which, thanks to his care and solicitude, grew rapidly; he continued to exercise his duties as delegated inspector to the very end of his life.

He accordingly supervised the following consultative conferences: twenty-four conferences of the Riazan railway's engineers (way and works); twenty-four conferences of locomotive engineers; sixteen conferences of traffic inspectors; eleven conferences of telegraph operators; three conferences of the medical department.

In consideration of the services he rendered to the technical sphere of railway works, the Moscow section of the Imperial technical society made him an honorary member in 1890.

Above and beyond his wonderful intimacy with all the branches of railway technical service, Mr. Adadourov possessed exceptional talent as an organizer and manager, shown in the exceedingly keen interest he took in humanitarian undertakings which gained him the esteem and respect of his men. Situated as he was at the head of such important enterprises as the Riazan-Koslov and Riazan-Ouralsk railways, the staff of which forms a regular army, the late Mr. Adadourov enjoyed the respect and sympathy of all his subordinates, and he never found one man among them who was not cordially devoted to him. When in 1884, there arose an agitation against him on the part of the shareholders of the Riazan-Koslov railway, and he was temporarily (for three years) ousted from the board of that undertaking, the railway staff sent him several addresses, evidencing their deep affection, wherein they expressed their complete sympathy with their chief and their wholesale sorrow at the fact that Mr. Adadourov had been removed from a position in which he had rendered such eminent services to all the company's servants. « It is with profound regret that we have learnt, » this address runs, « that after having taken so much trouble in order to carry through a difficult and troublesome piece of work, you are retiring from a task to which you have for our benefit consecrated the best years of your life, labouring for us, giving without thought your care and time to the humane works initiated for our benefit. »

And further on, the address states that thanks to the assistance or personal initiative of Mr. Adadourov, the dwellings for the use of the staff had been markedly improved, a splendid system of medical attendance had been instituted for the whole line, suitable quarters had been fitted up in the large stations for the staff waiting to come on duty, cheap bakeries had been established for the staff, free insurance of furniture had been introduced, schools for the children of railway employees had been opened, libraries had been formed, lectures had been organized, pension funds had been established for the men; in short, Mr. Adadourov, during his long career, had always conscientiously taken to heart all that appertained to the progress of the railways and to the welfare of their men. Now that this kind heart has ceased to beat, we can only express our profound and sincere sorrow, which is shared by all those who knew Mr. Adadourov intimately or distently. God rest the soul of this splendid man!

(Bulletin du Comité permanent des conférences consultatives des agents des différents services des chemins de fer russes.)

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Secretary General of the Permanent Commission of the International Railway Congress.

[016 .385. (02]

I. — BIBLIOGRAPHY OF BOOKS

(April, 1907.)

In French.

1907 **69** (02

GUÉDY (Henri), architecte.

La construction moderne pratique. (Résistance, maçonnerie, charpente, menuiserie, serrurerie, couverture, chauffage, peinture.)

Paris, imprimerie Mouillot; librairie Garnier frères. In-18 jésus, 523 pages et figures.

1907 **621** .13 (06.4

HERDNER (A.), ingénieur en chef adjoint à l'ingénieur en chef du matériel et de la traction de la Compagnie des chemins de fer du Midi français.

Les locomotives à l'exposition de Liége 1905.

Paris, Société des ingénieurs civils de France. In-8o (270 × 180), 186 pages.

1907 **621** .14 (02

IMBRECQ (J.), avocat à la Cour d'appel de Paris.

Le code du chauffeur. Recueil, commentaire et critique de toutes les lois intéressant les constructeurs, propriétaires et conducteurs d'automobiles.

Paris, imprimerie Dumoulin; librairie Dunod & Pinat. In-16, 486 pages. (Prix : 7.50 francs.)

1907 **385**. (09.1 (.44)

LAMBERT (Henri), contrôleur des comptes des chemins de fer au Ministère des travaux publics.

Monographie du réseau de l'Est.

Paris, Dunod & Pinat. 200 pages. (Prix : 3 francs.)

1906 **385**. (01 (.6)

Les chemins de fer en Afrique occidentale. Notices publiées, par le gouvernement général de l'Afrique occidentale française, à l'occasion de l'exposition coloniale de Marseille : I. Les chemins de fer du Sénégal. — II. Chemin de fer du Haut-Sénégal. Kayes au Niger. — III. Guinée, Côte d'ivoire, Dahomey.

Corbeil, imprimerie Crété. 3 volumes, in-8o, 220-168-190 pages.

1907 **385**. (09.1 (.4)

POULMAIRE (L.), graveur-éditeur géographe.

Carte spéciale des chemins de fer de l'Europe, à l'échelle du $^1/_{3,750.000}$.

Paris, chez l'auteur, 44, avenue du Maine (XIV^e). Grand-aigle (106 × 75). (Prix : cartes en feuille, 6 francs; sur toile, pliées et cartonnées, format de poche, 9 francs; collées sur toile, vernies, gorges et rouleaux, 11 francs.)

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(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels. (See "Bibliographical Decimal Classification as applied to Railway Science," by L. WEISSENBRUCH, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

N. B. — The Monthly Bibliography is printed on one side only so that it may be cut up into slips and pasted on labels for catalogues and indexes.

1907 **62.** (02

VIGREUX (Ch.), ingénieur des arts et manufactures; **MILANDRE** (Ch.), ingénieur civil, & **BOUQUET** (R. P.), ingénieur électricien.

Notes et formules de l'ingénieur et du constructeur mécanicien.

Paris, Bernard, éditeur. Quinzième édition, 1 volume in-16, 2,000 pages avec 1,500 figures. (Prix : 12.50 francs.)

In German.

1907 **625** .14 (02 & **656** .21 (02

BUROK (Emil), Bahnmeister.

Der Bahnmeister. Handbuch für den Bau- und Erhaltungsdienst der Eisenbahnen. II. Band. Birk (Alfred), Prof. Eisenb. Oberingen. **Die Praxis des Bau- und Erhaltungsdienstes der Eisenbahnen.** 3. Heft : Oberbau und Bahnhofsanlagen.

Halle, W. Knapp. In-8°, VIII-160 Seiten, 107 Abbildungen im Text. (Preis : 5 Mark.)

1907 **62.** (01

GLINZER (Dr. E.).

Kurzes Lehrbuch der Festigkeitslehre für Baugewerkschule und Baupraxis.

Leipzig, H. A. Ludwig Degener. 3. Auflage, in-8°, VIII-152 Seiten, mit 120 Textabbildungen und 34 Seiten Anhang. (Preis : 4 Mark.)

1906 **656** .235. (01

HÜLLER (Hermann), Ing. Maschinenkommissär der k. k. priv. Südbahngesellschaft.

Tarifsystem.

Wien, Selbstverlag.

1907 **313** .385 (.436)

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Der Eisenbeton. Formeln, Tabellen und Grundsätze zum Gebrauch für die Berechnung von Eisenbeton-Bauausführungen.

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Nashville, Tenn., Marshall & Bruce Co. Buckram, 276 pages. (Price : $5.)

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Lubrication and lubricants.

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The peabody atlas of coal mines and coal railroads in the central commercial district of the United States, accompanied by chemical, geological, and engineering data.

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Modern steam turbines, British and foreign ; comprising descriptions of some typical systems of construction. V. I, The Schulz steam turbine, for land and marine purposes, by Max Dietrich.

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Proceedings of the annual meeting held at Atlantic City, N. J., Jnne 13-15, 1906.

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German versus British railways. With special reference to owner's risk and trader's claims.

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REAGAN.

Locomotives : simple, compound and electric.

New York, John Wiley & Sons. Fifth edition, 12mo, 946 pages and 494 figures. (Price : $3.50.)

1907 **721** .9 (02

REID (Homer A.), Asssoc. M. Am. Soc. C. E.

Concrete and reinforced concrete construction.

New York, Myron C. Clark Publishing Co. 884 pages (9 1/4 × 6 inches), 715 illustrations in the text and 71 tables. (Price : $5.)

1907 **385**. (02

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Railway problems.

Boston, Ginn & Co. 8vo, xxxii-686 pages, with maps. (Price : $2.70.)

1907 **625** .142.2 & **691**

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1907 **62**. (02

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Jersey City, N. J., Charles M. Sames. Second edition. 16mo, 8 + 195 pages, diagrams. (Price : $2.)

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Encyclopedia of engineering. Treatise of boilers, steam engines, locomotives, electricity, automobile motors, refrigeration, etc.

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1906 **621** .33 (.45)

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1906 **624.** (09.3 (.44)

Annales des ponts et chaussées, 4e trimestre, p. 88.

Le pont de la Concorde sur la Seine, à Paris. (18,000 mots, 2 tableaux & fig.)

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Instructions relatives à l'emploi du béton armé. Circulaire ministérielle du 20 octobre 1906. (8,500 mots, tableaux & fig.)

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RÉSAL. — Rapport sur « l'autoloc », dispositif de blocage automatique et instantané, présenté au comité de l'exploitation technique des chemins de fer par la commission des inventions. (1,500 mots & fig.)

1906 **656** .211.4

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GOUPIL. — Principes adoptés pour les aménagements récents de grandes gares allemandes — Wiesbaden-Hambourg. (1,200 mots & fig.)

1907 **313** .385 (.485)

Annales des ponts et chaussées, I, p. 181.

Résultats généraux de l'exploitation des chemins de fer suédois en 1903 et 1902. (4 tableaux.)

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Résultats généraux de l'exploitation des chemins de fer canadiens pendant les exercices 1904-1905 et 1903-1904. (8 tableaux.)

Bulletin de l'Association du Congrès international des chemins de fer. (Bruxelles.)

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GOSS (W. F. M.). — Les essais de locomotives faits par le « Pennsylvania Railroad », à Saint-Louis. (12,000 mots, tableaux & fig.)

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VELLGUTH. — Les frais actuels des services d'omnibus automobiles. (13,000 mots & 4 tableaux.)

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1907 **385.** (07.11 & **727** .4

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Traverses employées par les chemins de fer des États-Unis en 1905. (650 mots & 3 tableaux.)

1907 **621** .132.3

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La locomotive compound « Prairie » des chemins de fer de l'État autrichien. (800 mots & fig.)

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Attelage automatique système Darling (construction avidson). (200 mots & fig.)

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Nécrologie : Alexander Johnston Cassatt. (2,100 mots & portrait.)

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1907 **621** .112
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COURTOY (F.). — Étude des distributions par pistons. (3,600 mots & fig.)

Bulletin de la Société d'encouragement pour l'industrie nationale. (Paris.)

1907 **621** .133.1
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Emploi du pétrole dans les locomotives aux États-Unis. (1,200 mots & fig.)

Bulletin de la Société des ingénieurs civils de France. (Paris.)

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BIRAULT (C.). — La ventilation des tunnels de chemins de fer et des métropolitains souterrains. (48,500 mots, tableaux & fig.)

Éclairage électrique. (Paris.)

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— nº 3, 19 — p. 80.

SOLIER (A.). — La traction électrique sur le métropolitain de Vienne. (4,200 mots & fig.)

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ALLEN (O.).— Les installations de traction électrique du Pennsylvania Railroad. (5,300 mots & fig.)

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CONSIDÈRE (A.).— Le béton fretté et ses applications. (4,000 mots & fig.)

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Machine à poser les bandages sur les roues de locomotives. (400 mots & fig.)

1907 **625** .254
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DANTIN (Ch.). — Le nouveau frein continu pneumatique, système Chapsal-Saillot. (2,200 mots & fig.)

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GUÉRIN (H.). — Éclairage des wagons par becs à incandescence. — Comparaison entre les becs droits et les becs renversés. (2,400 mots & fig.)

1907 **621** .132.5
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Locomotive compound à quatre essieux couplés du chemin de fer d'Anatolie. (450 mots & fig.)

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Le régime financier et l'organisation des chemins de er de l'État. (1,200 mots.)

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Appareils de levage électriques pour matériel de hemins de fer et tramways. (3,500 mots & fig.)

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BURLET (C. DE). — Les chemins de fer vicinaux en elgique. (15,000 mots.)

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SCHACHT (H.). — Instruction industrielle technique ux États-Unis d'Amérique. (5,800 mots.)

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ROSSIGNOL. — Transformation en quadruple voie le la double voie de Paris à Creil par Chantilly. 2,200 mots & fig.)

1907 **621** .133.7

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BOILEAU (H.). — Note sur l'épuration des eaux à la ompagnie des phosphates et du chemin de fer de Gafsa Tunisie). (5,000 mots, tableaux & fig.)

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Le Grand Trunk Pacific Railway. (1,200 mots & fig.)

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Tramway de Clermont-Ferrand au sommet du Puy-de-Dôme. (3,500 mots & fig.)

1907 **621** .134.3

Revue générale des chemins de fer, nº 3, mars, p. 159.

Application de la distribution Lenz aux locomotives. (900 mots & fig.)

1907 **656** .256.3 & **625** .4

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BALTZER. — Die Verstaatlichung der wichtigsten Privateisenbahnen in Japan und der koreanischen Eisenbahn von Söul nach Fusan. (5 000 Wörter & 1 Tabelle.)

1907 **385** .517 (.431)
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RÜDLIN. — Wohlfahrtseinrichtungen der preussisch-hessischen Eisenbahngemeinschaft im Jahre 1905. 12 000 Wörter & Tabellen.)

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ESCH. — Die Erhöhung der Ladefähigkeit und die Einführung der Selbstentladung bei den offenen Güterwagen der preussischen Staatsbahnen. (3 500 Wörter & 2 Tabellen.)

1907 **385**. (09.1 (.7)
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1907 **313** .385 (.434)
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Die Reichseisenbahnen in Elsass-Lothringen und die Wilhelm-Luxemburg-Bahnen im Rechnungsjahr 1905. (1 300 Wörter & Tabellen.)

1907 **313** .385 (.431)
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Die vereinigten preussischen und hessischen Staatseisenbahnen im Rechnungsjahr 1905. (800 Wörter & Tabellen.)

1907 **313** .385 (.433)
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Die bayerischen Staatseisenbahnen und Schiffahrtsbetriebe im Jahre 1905. (Tabellen.)

1907 **313** .385 (.434)
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Die Eisenbahnen in Grossherzogtum Baden im Jahre 1905. (Tabellen.)

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Die k. k. österreichischen Staatsbahnen im Jahre 1905. (500 Wörter & Tabellen.)

1907 **313** .385 (.44)
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Die Betriebsergebnisse der Staatsbahnen und der 6 grossen Eisenbahngesellschaften in Frankreich im Jahre 1905. (Tabellen.)

1907 **313** .385 (.439)
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NAGEL (R.). — Die Königlich ungarischen Staatsbahnen im Jahre 1905. (700 Wörter & Tabellen.)

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MARRIOTT (Willliam) & GRIBBLE (Theod. Graham). — Der Breydon Viaduct bei Great Yarmouth. (4 500 Wörter & Abb.)

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1907 **385** .21
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Die Verbundlokomotive, Type *Prairie*, der österreichischen Staatsbahn. (1 000 Wörter & Abb.)

1907 **625 .233**
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1907 **625 .253**
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Eine Verstopfung in der Bremsleitung. (200 Wörter.)

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Elektrische Bahnen und Betriebe. Zeitschrift für Verkehrs- und Transportwesen. (München.)

1907 **621 .33 & 625 .4**
Elektrische Bahnen u. Betriebe, Heft 8, 14. März, S. 146.
— — — 9, 23. — S. 161.

HEILFRON (C.).— Das Unterwerk « Bismarckstrasse » der Berliner elektrischen Hoch- und Untergrundbahn. (4 000 Wörter & Abb.)

Organ für die Fortschritte des Eisenbahnwesens in technischer Beziehung. (Wiesbaden.)

1907 **385.** (07.4
Organ für die Fortschritte des Eisenbahnw., 2. Heft, S. 27.

HÖHN (M.). — « Puffing Billy ». Nachbildung der im Kensington-Museum in London aufgestellten ältesten Lokomotive. (2 400 Wörter & Abb.)

1907 **725 .33**
Organ für die Fortschritte des Eisenbahnw., 2. Heft, S. 33.

ZIMMERMANN (F.). — Der Bau neuer Lokomotivschuppen. (1 500 Wörter.)

1907 **625 .233**
Organ für die Fortschritte des Eisenbahnw., 2. Heft, S. 35.

WEDLER. — Die Entwickelung der Personenwagen-Beleuchtung der preussisch-hessischen Staatseisenbahnen bis zum hängenden Gasglühlichte. (2 500 Wörter, 4 Tabellen & Abb.)

1907 **621 .132.8**
Organ für die Fortschritte des Eisenbahnw., 2. Heft, S. 40.

BORSIG (A.). — Zahn -und Reibungs-Lokomotive Nr 6000. (200 Wörter & Abb.)

1907 **656 .281**
Organ für die Fortschritte des Eisenbahnw., 2. Heft, S. 44.

Betriebsunfall bei Salisbury. (800 Wörter.) (S. *Bulletin du Congrès des chemins de fer*, nº 8, août 1906).

Schweizerische Bauzeitung. (Zürich.)

1907 **625 .11** (.494 + .45)
Schweizerische Bauzeitung, Nr 9, 2. März, S. 107.
— — Nr 10, 9. — S. 126.

Splügenbahn. (3 000 Wörter, 5 Tabellen & Abb.)

Zeitschrift für Architektur und Ingenieurwesen. (Wiesbaden.)

1907 **721 .4** (01
Zeitschrift für Architektur und Ingenieurw., Heft 1/2, S. 75.

HASSE. — Beitrag zur Bestimmung der Biegelinien beliebiger Fachwerke als Seilecke. (4 800 Wörter, Tabellen & Abb.)

Zeitschrift für Kleinbahnen. Berlin.

1907 **313 : 621 .33** (.42)
Zeitschrift für Kleinbahnen, Heft 3, März, S. 165.

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1907 **624 .51**
Zeitsch. des Vereines deutscher Ingen., Nr 10, 9. März, S. 361.

BARKHAUSEN (G.). — Die Kragträgerbrücke über den St. Lorenz-Strom bei Quebec in Kanada. (2 600 Wörter & Abb.)

1907 **625** .2 (06.4
Zeitsch. des Vereines deutscher Ingen., Nr 10, 9. März, S. 368.

METZELTIN. — Die Eisenbahnbetriebsmittel auf der Bayerischen Landesausstellung in Nürnberg 1906. (2 000 Wörter & Abb.)

1907 **621** .33 & **625** .13
Zeitsch. des Vereines deutscher Ingen., Nr 10, 9. März, S. 378.

RUPP (H.). — Der elektrische Betrieb der Simplon-Bahn. (3 800 Wörter, 1 Tabelle & Abb.)

1907 **656** .211 (.73)
Zeitsch. des Vereines deutscher Ingen., Nr 11, 16. März, S. 402.

GIESE (E.) & BLUM. — Personen -und Abstellbahnhöfe Nordamerikas. (3 600 Wörter & Abb.)

1907 **621** .33
Zeitsch. des Vereines deutscher Ingen., Nr 11, 16. März, S. 425.

ZWEILING (A.). — Die elektrischen Bahnen auf der Ausstellung in Mailand 1906. (1 200 Wörter & Abb.)

1907 **621** .132.3 (.42) & **621** .132.4 (.42)
Zeitsch. des Vereines deutscher Ingen., Nr 13, 30. März, S. 481.

LAKE (C. S.). — Neuerungen im Lokomotivbetrieb der London and North Western-Eisenbahn. (2 000 Wörter, 1 Tabelle & Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin)

1907 **385** .13
Zeitung des Vereins, Nr 18, 6. März, S. 275.

SCHULZE (W. A.). — Die Fahrpreiserhöhungen für die I. Wagenklasse der Eisenbahnzüge durch die Fahrkartensteuer. (2 000 Wörter.)

1907 **385** .524
Zeitung des Vereins, Nr 20, 13. März, S. 307.

KIENITZ (R. v.). — Beteiligung des Personals am Gewinn des Eisenbahnunternehmens. (1 800 Wörter.)

1907 **656** .222.1 (.73)
Zeitung des Vereins, Nr 23, 23. März, S. 363.

KUNTZEMÜLLER (A.). — Nochmals der Empire State express. (3 200 Wörter.)

1907 **347** .762
Zeitung des Vereins, Nr 24, 27. März, S. 379.

HERTZER (W.). — Der Gepäckbeförderungsvertrag. (3 400 Wörter.)

1907 **621** .132.8
Zeitung des Vereins, Nr 25, 30. März, S. 395.

FRAHM. — Triebwagen und leichte Personenzüge auf den englischen Eisenbahnen. (1 100 Wörter & Abb.)

Zentralblatt der Bauverwaltung. (Berlin.)

1907 **656** .256
Zentralblatt der Bauverwaltung, Nr 19, 2. März, S. 134.
— — Nr 21, 9. — S. 146.

SEYFFERT. — Vorschlag zur Vervollkommnung der Blocksperren für Eisenbahn-Signalstellwerke. (1 800 Wörter & Abb.)

In English.

American Engineer and Railroad Journal. (New York.)

1907 **625** .232
American Engineer & R. Journal, No. 3, March, p. 81.

Steel passenger car. (2,500 words & fig.)

1907 **621** .132.5 & **621** .134.3
American Engineer & R. Journal, No. 3, March, p. 88.

Santa Fe type locomotive with smokebox superheater. (1,000 words & fig.)

American Machinist. (New York.)

1907 **621** .94
American Machinist, No. 9, March 16, p. 276.

A new 16-inch toolmakers' lathe. (200 words, 2 tables & fig.)

1907 **389**
American Machinist, No. 10, March 23, p. 328.

Some gaging and measuring methods in American and British shops. (2,100 words & fig.)

Bulletin of the International Railway Congress Association. (Brussels.)

1907 **656** .223.2
Bulletin of the Railway Congress, No. 3, March, p. 271.

ALLEN (W. F.). — The interchange use of freight cars in North America. (4,700 words.)

1907 **656** .211 & **656** .212
Bulletin of the Railway Congress, No. 3, March, p. 281.

TOLLER (E.). — Rearrangement of the Leipzig stations of the Saxon State Railway. (3,600 words & fig.)

1907 **656** .259
Bulletin of the Railway Congress, No. 3, March, p. 289.

LUX (Friedrich.). — Frahm's speed and frequency gauge. (4,500 words & fig.)

1907 551 .51 & 621 .39
Bulletin of the Railway Congress, No. 3, March, p. 301.

GOLDSCHMIDT (R.). — Electric anemometer. (1,000 words & fig.)

1907 621 .133.5
Bulletin of the Railway Congress, No. 3, March, p. 305.

American Engineer tests on locomotive draft appliances. (3,300 words & fig.)

1907 385. (07.11
Bulletin of the Railway Congress, No. 3, March, p. 312.

The new engineering building of the University of Pennsylvania. (3,600 words & fig.)

1907 656 .27
Bulletin of the Railway Congress, No. 3, March, p. 319.

Organization of a cheap service on a main railway's ranch lines which carry little traffic and on light ailways (question XIX, 7th session). Discussion. (6,800 vords.)

1907 621 .14
Bulletin of the Railway Congress, No. 3, March, p. 337.

Traffic conveyed by automobiles (question XX, th session). Discussion. (9,200 words & fig.)

1907 625 .143.2
ulletin of the Railway Congress, No. 3, March, p. 361.

JOB (Robert). — Steel rails : their composition and oss-section. (1,650 words.)

1907 625 .143.5
ulletin of the Railway Congress, No. 3, March, p. 364.

Trials of the Lakhovsky screwspike. (3,100 words & fig.)

1907 625 .216
ulletin of the Railway Congress, No. 3, March, p. 373.

The Darling automatic coupler. (Davidson pattern.) 00 words & fig.)

1907 625 .254
illetin of the Railway Congress, No. 3, March, p. 375.

Erratic actions of the vacuum brake. (900 words.)

1907 621 .134.3
lletin of the Railway Congress, No. 3, March, p. 377.

Single expansion and lower pressures. (1,000 words.)

1907 016 .385. (0
lletin of the Railway Congress, No. 3, March, p. 31.

Monthly bibliography of railways. — Books. (26 labels.)

1907 016 .385. (05
lletin of the Railway Congress, No. 3, March, p. 34.

Monthly bibliography of railways. — Periodicals 5 labels.

Engineer. (London.)

1907 624 .8
Engineer, No. 2670, March 1, p. 207.

The new Nile bridges at Cairo. (1,300 words & fig.)

1907 621 .134.4
Engineer, No. 2670, March 1, p. 217.

Compound v. simple locomotives. (2,700 words & fig.)

1907 625 .112 (.54)
Engineer, No. 2671, March 8, p. 227.

Railway gauges of India. (1,600 words.)

1907 621 .97
Engineer, No. 2671, March 8, p. 246.

108-ton pneumatic hammer. (1,400 words & fig.)

1907 621 .14
Engineer, No. 2673, March 22, p. 299.

BEAUMONT (W. W.). — Petrol motor omnibuses. (5,800 words & fig.)

1907 621 .132.3
Engineer, No. 2674, March 29, p. 306.

ROUS-MARTEN (C.). — New type of Great Western express engine : an evolution. (3,000 words & fig.)

Engineering. (London.)

1907 385 .1 (.42)
Engineering, No. 2148, March 1, p. 279.

The railway situation. (1,200 words.)

1907 625 .13
Engineering, No. 2149, March 8, p. 297.

PRELINI (C.). — The New York subaqueous tunnels. (1,800 words & fig.)

1907 625 .174
Engineering, No. 2149, March 8, p. 308.

Snow-plough for the Caledonian Railway. (350 words & fig.)

1907 625 .232
Engineering, No. 2149, March 8, p. 307.
— No. 2150, — 15, p. 335.

Metre-gauge royal train for India. (2,600 words & fig.)

1907 385 .15 (.44)
Engineering, No. 2150, March 15, p. 351.

The purchase of the Western Railway of France. (3,000 words.)

1907 621 .14
Engineering, No. 2151, March 22, p. 395.

BEAUMONT (W. W.). — Petrol motor omnibuses. (6,600 words & fig.)

1907 **624** .2

Engineering, No. 2152, March 29, p. 407.

STONEY (E. W.). — Strengthening girder bridges on the Madras Railway. (1,800 words & fig.)

1907 **621** .132.3

Engineering, No. 2152, March 29, p. 419.

New express locomotive for the Swedish State Railways. (250 words & fig.)

Engineering Magazine. (London.)

1907 **621** .13 & **621** .33

Engineering Magazine, March, p. 883.

WERNER (G. B.). — The cost of steam and electric locomotive operation. (1,700 words.)

1907 **621** .7

Engineering Magazine, March, p. 918.

KNOEPPEL (C. E.). — Cost reduction through cost comparison. (2,000 words, tables & fig.)

Engineering News. (New York.)

1907 **625** .13

Engineering News, No. 9, February 28, p. 223.

FORGIE (J.). — The construction of the Pennsylvania R. R. tunnels under the Hudson River at New York City. (7,500 words, tables & fig.)

1907 **625** .13

Engineering News, No. 10, March 7, p. 254.

ARTINGSTALL (Wm.). — Progress of work in lowering the tunnels under the Chicago River. (1,300 words & fig.)

1907 **656** .256.3

Engineering News, No. 10, March 7, p. 255.

Automatic electric block signaling on the Boston & Maine Railway. (2,000 words & fig.)

1907 **656** .281

Engineering News, No. 11, March 14, p. 296.

Some facts and figures bearing on the Bronx Park derailment on the New York Central. (4,000 words & fig.)

1907 **388** (.42) & **621** .33 (.42)

Engineering News, No. 12, March 21, p. 311.

The rapid transit systems of London. (4,000 words, 3 tables & fig.)

Great Western Railway Magazine. (London.)

1907 **656** .253

Great Western Railway Magazine, March, p. 55.

The Great Western system of audible signals. (900 words & fig.)

Indian Engineering. (Calcutta.)

1907 **621** .132.3

Indian Engineering, No. 7, February 16, p. 112.

New type of heavy passenger engine, North Western Railway. (250 words & fig.)

Locomotive Firemen and Engineer's Magazine. (Indianapolis.)

1907 **621** .134.2

Locom. Firemen and Engineer's Magazine, March, p. 341.

WOOD (W. W.). — Questions and answers on the Walschaerts locomotive valve gear. (8,000 words & fig.)

Locomotive Journal. (Leeds.)

1907 **625** .143.1

Locomotive Journal, March, p. 111.

The evolution of the railway rail upon the Midland Railway. (500 words & fig.)

Proceedings of the American Society of Civil Engineers. (New York.)

1907 **624** .8

Proceed. of the Amer. Soc. of Civil Eng., No. 2, Febr., p. 153.

SCHNEIDER (C. C.). — Movable bridges. (13,000 words & 1 table.)

Railroad Gazette. (New York.)

1907 **621** .13 (09.3 (.73)

Railroad Gazette, No. 8, February 22, p. 235.

CARUTHERS (C. H.). — Successive experiments and improvements on locomotives of the Pennsylvania Railroad. (5,000 words & fig.)

1907 **625** .243 & **625** .246

Railroad Gazette, No. 8, February 22, p. 250.

All-steel 50-ton box car for the Union Pacific. (400 words & fig.)

1907 **621** .336

Railroad Gazette, No. 9, March 1, p. 273.

MAYER (J.). — A new form of suspension for contact wires. (2,200 words & fig.)

1907 **656** .256 (.73)
Railroad Gazette, No. 9, March 1, p. 277.

Government report on the block system. (5,000 words.)

1907 **621** .132.5
Railroad Gazette, No. 10, March 8, p. 296.

Consolidation locomotive for the Nippon Tetsudo Kwaisha Railroad. (600 words & fig.)

1907 **656** .261 (.42)
Railroad Gazette, No. 10, March 8, p. 300.

The British system of cartage and delivery of freight at terminals. (1,300 words & fig.)

1907 **621** .135.4 & **625** .215
Railroad Gazette, No. 11, March 15, p. 327.

Stresses in tracks on curves. (1,000 words & fig.)

1907 **625** .13
Railroad Gazette, No. 11, March 15, p. 328.

The Bay Shore and Dumbarton Cutt-Offs of the Southern Pacific. (1,400 words & fig.)

1907 **625** .142.3
Railroad Gazette, No. 11, March 15, p. 336.

LINDENTHAL (G.). — A longitudinal steel sleeper system for railroad track. (700 words, 1 table & fig.)

1907 **625** .13
Railroad Gazette, No. 11, March 15, p. 338.

Method of placing heavy double-track through plate girders on the Union Pacific. (400 words & fig.)

1907 **625** .13
Railroad Gazette, No. 11, March 15, p. 347.

The Tidewater and the Deepwater Railways. — Culverts, track and tunnels. (2,500 words & fig.)

1907 **625** .1 (.73)
Railroad Gazette, No. 11, March 15, p. 351.

FOWLER (G. L.).— Norfolk & Western improvement work. (3,800 words & fig.)

1907 **625** .14 (01
Railroad Gazette, No. 11, March 15, p. 363.

CUENOT (G.). — Track deformations and their prevention. (3,200 words, 1 table & fig.)

1907 **656** 256.3
Railroad Gazette, No. 11, March 15, p. 368.

Upward-inclination three-position signals, on the P., B. & W. (1,800 words & fig.)

1907 **656** .25 (01
Railroad Gazette, No. 12, March 22, p. 405.

New and old signaling problems. (4,800 words.)

1907 **656** .281
Railroad Gazette, No. 12 March 22, p. 415.

Comparative effects of steam and electric locomotives on a 3-deg. curve. (1,000 words, 1 table & fig.)

Railway Age. (Chicago.

1907 **656** .256
Railway Age, No. 1601, February 15, p. 205.

SALMON (W. W.). — Controlled manual block system in use on single track line of the Illinois Central Railroad. (4,200 words & fig.)

1907 **621** .132.5
Railway Age, No. 1601, February 15, p. 210.

Pittsburg Shawmut & Northern 10-coupled locomotive. (400 words & fig.)

1907 **621** .135.2
Railway Age, No. 1604, March 8, p. 311.

HENDERSON (G. R.). — The relation of locomotive wheel base to track curvature. (900 words.)

1907 **725** .43
Railway Age, No. 1604, March 8, p. 321.

The Battle Creek locomotive shops of the Grand Trunk Railway. (2,000 words & fig.)

1907 **624** .32
Railway Age, No. 1606, March 22, p. 385.

Missouri River bridge of the Chicago Milwaukee & St. Paul at Mobridge, S. D. (2,700 words & fig.)

1907 **625** .13
Railway Age, No. 1606, March 22, p. 392.

Bronx improvement of the New York Central. (1,400 words & fig.)

1907 **656** .281
Railway Age, No. 1606, March 22, p. 499.

Report of a board of engineers on New York Central locomotives as relating to the Woodlawn wreck. (2,200 words, tables & fig.)

Railway Engineer. (London.)

1907 **621** .132.3
Railway Engineer, No. 326, March, p. 73.

New 4-6-0 type engines; Great Central Railway. (500 words & fig.)

1907 **656** .257
Railway Engineer, No. 326, March, p. 84.

Signalling on the Great Northern & City Railway. (800 words & fig.)

1907 **621** .132.8
Railway Engineer, No. 326, March, p. 86.

Rail motor cars; Great Northern Railway (Ireland). (1,000 words & fig.)

Railway and Engineering Review. (Chicago.)

1907 **656** .281
Railway and Engineering Review, No. 7, February 16, p. 123.

SLIFER (H. J.). — Derailment on curves. (1,000 words.)

1907 **656** .235.2 (.73)
Railway and Engineering Review, No. 7, February 16, p. 124.

Regulations concerning the filing of freight tariffs and classifications. (2,600 words.)

1907 **656** .234 (.73)
Railway and Engineering Review, No. 8, February 23, p. 148.

Regulations governing the construction and filing of passenger tariffs. (3,200 words.)

1907 **625** .142.2 & **691**
Railway and Engineering Review, No. 9, March 2, p. 173.

CHANUTE (O.). — Steaming timber before treating with preservative. (1,600 words.)

1907 **656** .254
Railway and Engineering Review, No. 10, March 9, p. 184.

The application of the telephone to railway service. (1,200 words.)

1907 **656** .256.3
Railway and Engineering Review, No. 11, March 16, p. 202.

Trial of new signals on the P. R. R. (2,200 words & fig.)

1907 **656** .256 (.73)
Railway and Engineering Review, No. 11, March 16, p. 207.

Report of Interstate Commerce Commission on block signals. (24,000 words, 4 tables & fig.)

Railway Gazette. (London.)

1907 **656** .253
Railway Gazette, No. 9, March 1, p. 202.

The Great Western Railway Company's system of audible distant signals (1,200 words & fig.)

1907 **621** .133.4
Railway Gazette, No. 10, March 8, p. 224.

Smoke prevention apparatus for locomotives (Staby system). (700 words & fig.)

1907 **625** .243 & **625** .246
Railway Gazette, No. 10, March 8, p. 234.

All-steel 50-ton box car for the Union Pacific. (300 words & fig.)

1907 **656** .256 (.73)
Railway Gazette, No. 11, March 15, p. 253.

Government report on the block system. (500 words.)

1907 **621** .14 (01
Railway Gazette, No. 13, March 29, p. 301.

CUENOT (G.). — Track deformations and their prevention. (3,200 words, 1 table & fig.)

1907 **656** .256.3
Railway Gazette, No. 13, March 29, p. 306.

Upward-inclination three-position signals on the P., B. & W. (1.800 words & fig.)

Railway and Locomotive Engineering. (New York.)

1907 **625** .174
Railway and Locomotive Engineering, March, p. 99.

The rotary in the rockies. (1,000 words & fig.)

Railway Machinery. (New York.)

1907 **621** .13 (01
Railway Machinery, March, p. 358.

The actual efficiency of a modern locomotive. (2,300 words.)

Railway Magazine. (London.)

1907 **656** .222.1 (.42)
Railway Magazine, No. 117, March, p. 242.

ROUS-MARTEN (O.). — British locomotive practice and performance. (2,800 words & fig.)

Railway Maintenance and Structures. (New York.)

1907 **625** .13
Railway Maintenance and Structures, No. 2, February, p. 19.

FRANCIS (G. B.) & DEUNIS (W. F.). — The Scranton tunnel of the Lackawanna and Wyoming Valley Rail road. (7,000 words, 1 table & fig.)

1907 **656** .212 (.73)
Railway Maintenance and Structures, March, p. 52.

NORTH (H. M.). — The theory of the design of railway freight terminals. (9,800 words, 2 tables & fig.)

Railway Times. (London.

1907 656 .253
Railway Times, No. 9, March 2, p. 237.

Audible signals on the Great Western Railway. (1,000 words & fig.)

1907 625 .174
Railway Times, No. 10, March 9, p. 257.

New Caledonian swow plough. (150 words & fig.)

1907 385. (01 (.67)
Railway Times, No. 13, March 30, p. 329.

The Benguella Railway. (1,400 words, 1 table & fig.)

South African Railway Magazine. (Johannesburg.)

1907 385. (01 (.6)
South African Railway Magazine, No. 7, March, p. 386.

MICHELL (Sir Lewis). — Cape to Cairo railway. 5,000 words.)

Street Railway Journal. (New York)

1907 621 .335
Street Railway Journal, No. 9, March 2, p. 386.

New electric locomotive of the Boston Elevated Railway Company. (900 words & fig.)

1907 621 .335
treet Railway Journal, No. 12, March 23, p. 488.

Electric freight locomotive built by the Brooklyn Rapid Transit Company. (900 words & fig.)

Tramway & Railway World. (London.)

1907 621 .336
ramway & Railway World, March, p. 181.

The Dolter surface contact system. (3,500 words & fig.)

1907 621 .33
ramway & Railway World, March, p. 189.

The London and North Western Electric Railway. ,600 words & fig.)

In Italian.

ngegneria ferroviaria. (Roma.)

1907 621 .33 (01
gegneria ferroviaria, nº 5, 1º marzo, p. 68.

JERVIS (T.). — I problemi meccanici nella trazione ettrica in teoria ed in pratica. (2,500 parole & fig.)

1907 621 .33 (.494)
Ingegneria ferroviaria, nº 5, 1º marzo, p. 70.

GERLI (E.). — Gli studi per la trazione elettrica in Svizzera. (3,200 parole.)

1907 621 .13 (06.4
Ingegneria ferroviaria, nº 5, 1º marzo, p. 76.

CERRETI (U.). — L'esposizione di Milano. — Le locomotive estere. (2,200 parole & fig.)

1907 621 .133.7 & 725 .33
Ingegneria ferroviaria, nº 5, 1º marzo, p. 80.
— — nº 6, 16 — p. 92.

CODA (C.). — La rifornitura accelerata dell' acqua alle locomotive dei treni, sulle linee del Compartimento di Firenze delle ferrovie dello Stato. (3,300 parole & fig.)

1907 621 .95
Ingegneria ferroviaria, nº 6, 16 marzo, p. 89.

Perforatrici elettriche. (650 parole, 3 tavole & fig.)

1907 621 .132.3
Ingegneria ferroviaria, nº 6, 16 marzo, p. 91.

GÖLSDORF (K.). — Nuove locomotive tipo « Prairie » delle ferrovie dello Stato Austriaco. (550 parole & fig.) (V. *Bulletin du Congrès des chemins de fer*, nº 3, mars 1907.)

1907 621 .335
Ingegneria ferroviaria, nº 6, 16 marzo, p. 95.

I locomotori gruppo 36 delle ferrovie elettriche Valtellinesi. (550 parole & fig.)

Giornale del genio civile. (Roma.)

1907 621 .33
Giornale del genio civile, febbraio, p. 64.

VISCIDI (P.). — Accertamento dei corti circuiti nelle istallazioni di trazione elettrica. (850 parole & fig.)

1907 621 .13 (06.4
Giornale del genio civile, febbraio, p. 77.

Le locomotive a vapore nella mostra ferroviaria di Milano. (2,400 parole & 1 tavole.)

1907 621 .33
Giornale del genio civile, febbraio, p. 84.

La costruzione del binario nelle tramvie urbane. (4,800 parole, 1 tavole & fig.)

Rivista generale delle ferrovie e dei lavori pubblici. (Firenze.)

1907 **621** .132.7 & **621** .335

Rivista generale delle ferrovie, nº 10, 10 marzo, p. 149.

Locomotiva mista per le ferrovie belghe di Stato. 1,300 parole.) (V. *Bulletin du Congrès des chemins le fer*, nº 2, février 1907.)

In Spanish.

Gaceta de los caminos de hierro. (Madrid.)

1907 **621** .132.1 (.73)

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BULLETIN
OF THE
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[625 .216]

FRICTION GEAR FOR RAILWAY COUPLINGS,

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Figs. 1 and 2, pp. 590 and 591.

Everybody admits to-day that it is advisable to strengthen the couplings of the long trains hauled by the modern powerful locomotives; but it becomes absolutely necessary to do so if such trains are to be equipped with the continuous brake.

One of the most interesting schemes proposed for increasing the resistance of couplings, is the application of friction gear, that is, of apparatus which converts the greater part of the energy absorbed into heat.

Recent trials made on the Belgian State Railway prove the efficiency of such gear, and it may be of interest to show the importance of its action when long trains are braked.

The trials were made with two kinds of brakes, the comparative value of which we do not propose to discuss here; for the sake of simplicity we will call them A and B.

Brake A is characterized by the very rapid transmission of the fall of pressure in the main pipe and by the quick action of the brake cylinder. In brake B the transmission is slower and the brake cylinder also acts more slowly.

The two trial trains consisted of a bogie dynamometer car weighing 35 tons and of eighteen carriages and vans, six-wheeled, and weighing on the average 22 tons each. Each of the cars forming the train equipped with brake A, except the dynamometer car, had its drawbar fitted with Westinghouse friction gear. The cars of the train equipped with brake B had the ordinary Belgian State Railway couplings.

Thus, train A was equipped with a quick-acting brake and friction draft gear, train B with a slower brake and ordinary couplings.

We may at once remark that the use of the friction gear made it possible to increase the pressure of the brake blocks of train A on the tires to 81·5 per cent of the weight of the cars, and to make emergency stops at all speeds without having a train-break. With the train B, on the other hand, the brake pressure could attain only 75 per cent, and that with difficulty. Thus friction gear has this first great advantage that a quicker brake and greater brake pressure can be used.

The apparatus in the dynamometer car (¹) enabled the following records to be obtained during each braking :

1° Diagram showing the pressure of the brake blocks on the wheels;

2° Diagram showing the tangential force developed by the friction of the brake blocks (pressure multiplied by coefficient of friction);

3° Diagram showing the total retarding force acting on the train (obtained by means of the Desdouits inertia dynamometer);

4° Diagram showing the tensile and compressive stresses acting on the coupling between the tender and the dynamometer car.

Pencils operated electrically marked datum points on the different records, so that it was possible to combine the curves and obtain figures 1 and 2 which we will now examine.

In these two figures;

1 is the curve showing the pressure of the brake blocks on the wheels;

2 is the curve showing the tangential force;

3 is the curve showing the total retarding force as recorded by the Desdouits apparatus;

4 is the curve showing the stresses acting on the coupling between the tender and the dynamometer car. (AB being the zero line of the dynamometer spring, the ordinates above this line show the tensions and those below the compressions.)

No scales to enable the exact values of all these forces to be determined are given; for the purposes of our argument we need only consider the general shape of the curves.

The examination of the two figures shows firstly that the tangential force is nearly proportional to the brake-block pressure, except at the lower speeds. When considering the subject of couplings, we may therefore assume the coefficient of friction to be practically constant at speeds over about 30 kilometres (18·6 miles) per hour; but at slower speeds and until the actual stop, the increase in the coefficient of friction is very important and has to be taken into consideration.

(¹) For a description of this car, see *Bulletin of the Railway Congress*, December, 1905, p. 2361.

A second and important conclusion results from a comparison of the Desdouits curve with the curve showing the stresses in the coupling.

The figures show that any increase in the tension of the coupling (curve 4) is attended by, or more accurately is preceded by, a rise in the Desdouits curve (curve 3), such rise showing an increase in the total retarding force. All dangerous tension in the coupling arises therefore from the increase of retarding forces acting on the cars of the trains, and not from any causes tending to reduce the negative acceleration of the locomotive and tender.

This observation proves the theories correct that as regards the fracture of couplings, supreme weight is to be attached to the movement of the water in the tender and in the boiler, to the reduction in the coefficient of friction during the first few moments the brake was applied, etc.

The careful examination of the curve recording stresses in the coupling leads to other even more important conclusions.

Figure 1, which refers to the train equipped with brake A and friction draft gear, shows that there are two maximums in the coupling-stress curve, CE and DF.

The first, CE, is due to the development of the braking force; as this extends towards the tail of the train, the cars, compressing their drawsprings, are affected by a relative recoil on the drawbar, thus producing dynamic forces which add up producing the tension CE.

It follows from the preceding :

1° That the couplings of the front cars are more strained, and that consequently there is a greater chance of couplings breaking in the front part of the train; experience confirms this:

2° That in order to resist the sum total of all the dynamic forces which act on the drawbar, the coupling should have much dynamic resistance, that is to say, it should be able to take up a large number of kilogram-metres (¹). Static resistance is of much less importance. Friction gear is therefore absolutely necessary for quick and effective braking (²);

3° That as the magnitude of the maximum tension CE produced depends on the number of cars and on the braking force on each, it is reasonable to adopt two different values for the working pressure in the main pipe : a lower one with long trains, a higher one with short trains.

In the case of passenger trains, this measure will have the additional advantage of making the mean braking force, per ton of train, more uniform. For the fact

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(¹) Our drawsprings can hardly take up 200 kilogram-metres (1,447 foot-pounds), whereas the weakest pattern of Westinghouse friction gear takes up 800 kilogram-metres (5,788 foot-pounds) before it has finished its travel.

(²) This shows the utter impractability of trying to use high-pressure brakes before drawgear has been improved.

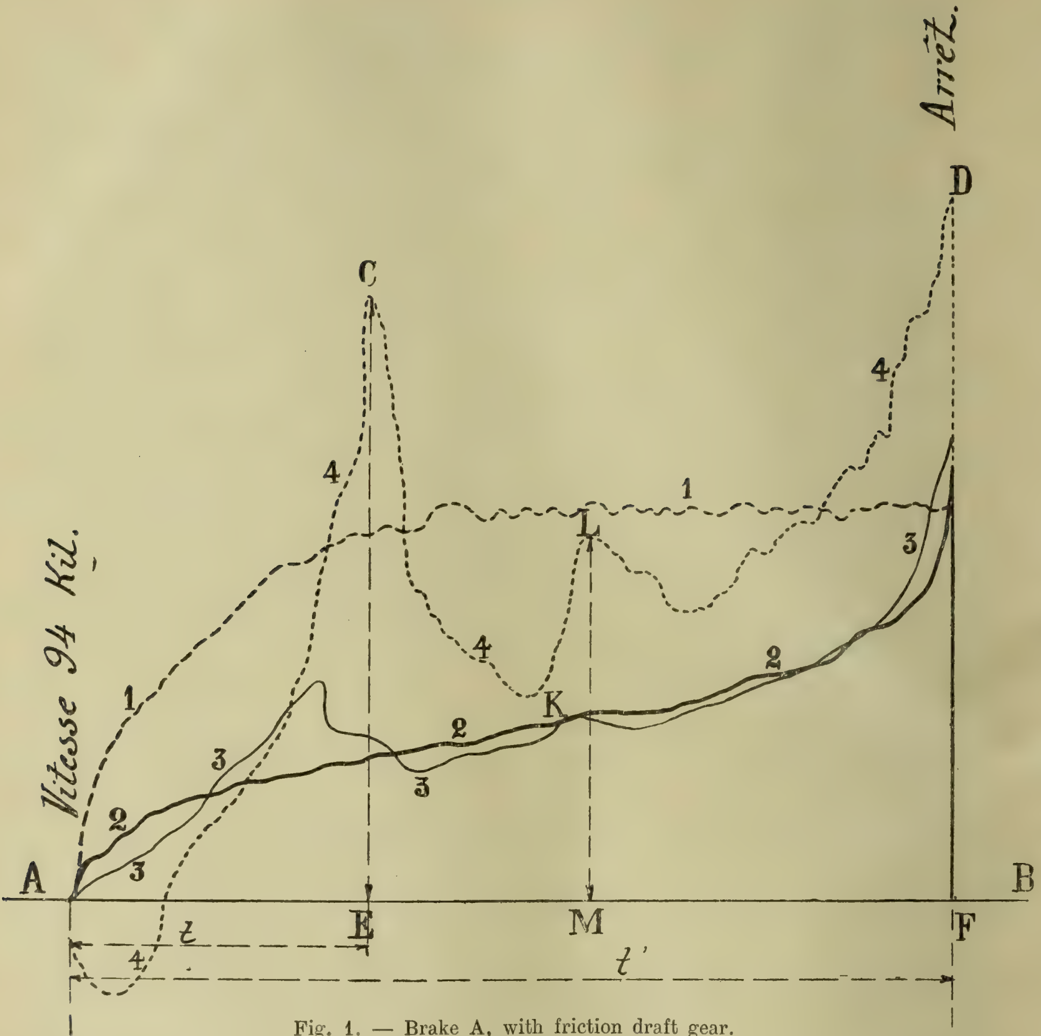

Fig. 1. — Brake A, with friction draft gear.

Explanation of French terms : Arrêt = Stop. — Vitesse 94 kil. = Speed 94 kilometres (58·4 miles) per hour.

that locomotive is always braked less than the cars, tends to lower the mean percentage of braking force and all the more so because the train is shorter; moreover the longer trains generally run at lower speeds.

In the case of goods trains, the adoption of two pressures will probably be one of the most valuable means available for improving the insufficiency of braking force on trains consisting chiefly of loaded trucks.

Now continuing the examination of our diagrams, we find that the second dangerous tension of the couplings, DF, begins to develop when the speed is about 30 kilo-

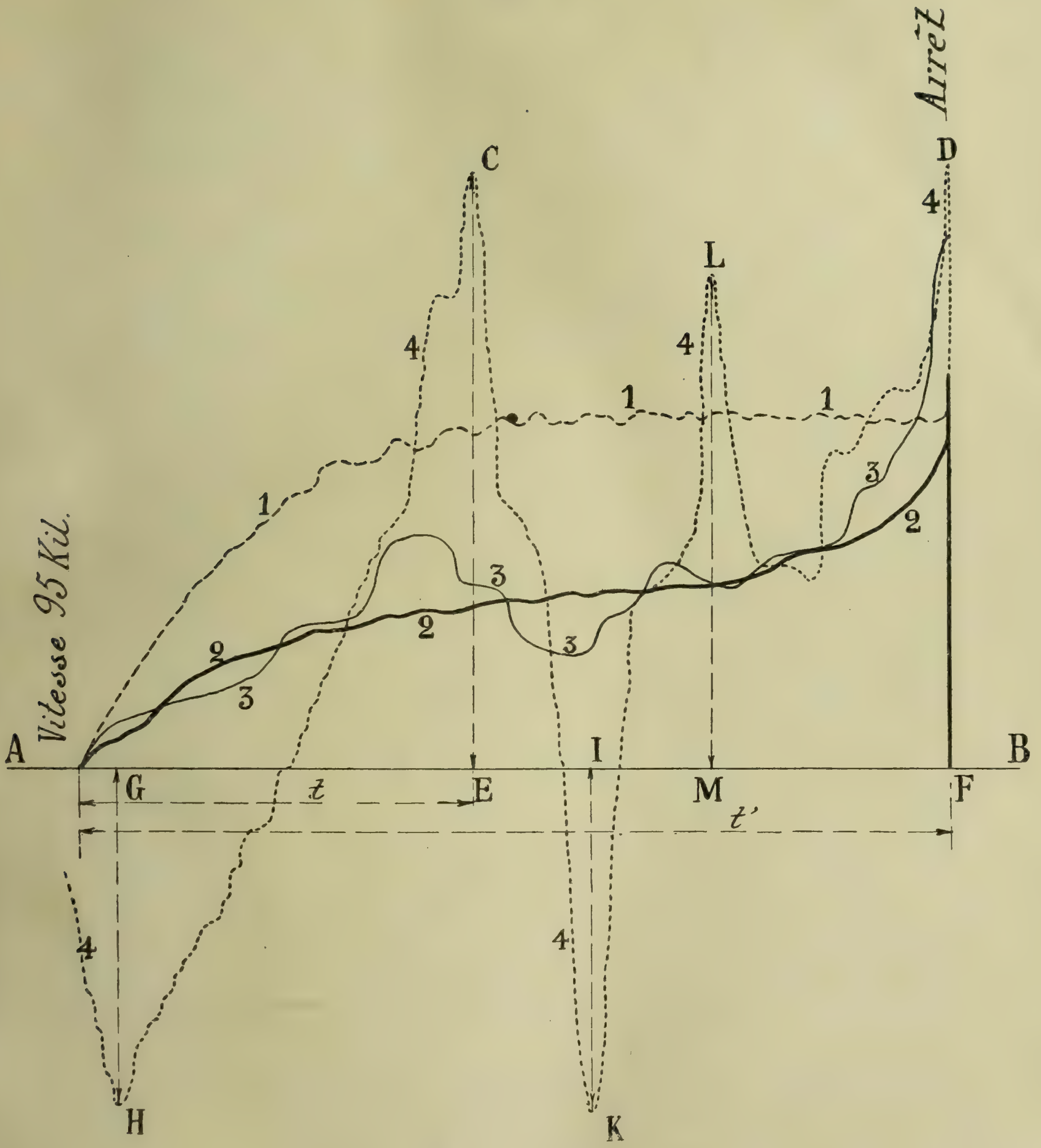

Fig. 2. — Brake B, with ordinary couplings.

Explanation of French terms : Arrêt = Stop. — Vitesse 95 kil. = Speed 95 kilometres (59 miles) per hour.

metres (18·6 miles) per hour; the maximum is reached at the actual stop of the train. The variations correspond very accurately with those in the coefficient of friction; and this allows us to conclude that this maximum is due to the increase in the coefficient of friction, together with the fact mentioned above, that the locomotive of a passenger train is always braked less than the carriages. Here again dynamic resistance in drawgear will often be necessary in the case of long trains.

We will now mention to what cause we attribute the greater number of the train-breaks which occur.

Unfortunately we were unable to obtain diagrams showing the phenomena clearly, because when a coupling was broken, the records obtained by the apparatus were nearly always falsified by the violence of the reactions; at present we can only submit a theory, but this theory has the merit of explaining the well-known law of critical speeds in connection with braking. The future will show whether the theory proposed is correct.

It is a matter of general knowledge that with a train of given composition equipped with a given brake, there is a certain range of speeds (40 to 50 kilometres [24·8 to 31 miles] per hour, for instance), within which an " emergency stop " application of the brakes almost invariably results in a broken coupling; whereas at higher speeds or lower speeds, as long as outside that range of *critical speeds*, emergency stops are made without trouble.

Of the two dangerous maximums CE and DF shown in figure 1, the first is produced t seconds after the braking of the dynamometer car begins, and the second t' seconds after, that is to say at the moment of actual stop. The length of the time t depends on the number of cars in the train, and on the behaviour of the brake (time of transmission in the main pipe, time required for pressure in brake cylinder). This time t is thus *constant* for a given train. The time t' on the other hand, that is to say, the time required for stopping the train, depends mainly on the initial speed of the braking; therefore, the position of the maximum tension DF relatively to the maximum tension CE depends on the initial speed.

At high speeds (as in our figures), tension DF is produced long after tension CE. At low speeds, tension DF will be produced before tension CE; that is to say the train will be stopped before the latter tension can become developed. At those intermediate speeds to which we have given the name " critical speeds ", these two maximums will become developed nearly simultaneously, and their addition will produce very high stresses in the coupling.

Let us now consider figure 2, which refers to a train equipped with brake B and ordinary couplings; we will make several interesting observations there and discover a very important property of friction gear.

We see that brake B, to begin with, produces a strong compression GH in the coupling; this results from the comparative slowness in the transmission of the action. Later on, there are the two maximums CE and DF; but the most remarkable feature of the diagram is the pair of secondary maximums, IK and LM, negative and positive, which are apparently absent in figure 1. We say " apparently ", for although they do not appear as maximums, it is easy to see that the effects are there (points K and L), but were not able to develop. These dangerous secondary tensions thus do not depend on the system of brake used; they are due to the reaction of the couplings. And if they are reduced to very nearly nil in the case of figure 1, this is due to the friction gear, which has the valuable property of converting the greater part of the energy absorbed into heat, whereas ordinary springs such as those of train B return nearly all the energy they have momentarily stored up.

This difference is of paramount importance, for the presence of a second maximum LM in the case of braking B (fig. 2) doubles the risk of the maximum DF occurring simultaneously with the one or other dangerous tension; consequently there is much greater chance of a fractured coupling.

To sum up, friction gear has the following effect in the braking of passenger trains :

1° It opposes a considerable dynamic resistance to the sum of the dynamic forces which act on the drawbar during the first few moments while the brakes come into action ;

2° It converts the greater part of such dynamic forces very quickly into heat, and thus reduces the duration of the critical period during which the maximums in the drawbar tension may occur simultaneously ;

3° If those maximums do occur simultaneously, it opposes to them a strong dynamic resistance ;

4° It reduces the magnitude of the dynamic forces, the injurious effect of which we have seen. This is an other interesting point in the important functions of friction gear.

For as the dynamic forces are produced by the recoil of the vehicle on its drawbar, compressing its drawspring, under the action of the brake, it is evident that they will be smaller by as much as the recoil will be less. Now friction gear reduces this recoil to a minimum, as it materially increases the resistance of the drawspring while travelling.

In all these cases, we have not considered the question of the compression of the couplings. Now figure 2 shows us that with a slow-acting brake, this compression GH may have a certain magnitude. However, during our numerous experiments on very long passenger trains, no record was obtained of any considerable forward shock being produced by the buffers being driven home. We may therefore conclude that for such trains the quickness of action of our present air brakes is such that our buffers meet all requirements.

But this is no longer the case with goods trains of fifty wagons ; and then it is important to have sufficiently quick transmission to prevent the violent compression to the front part of the train.

This compression has rarely any evil effects as regards fracture of couplings pure and simple; for the forward shocks, when the buffers are driven home, act on the buffer casings and the underframe, that is on very strong parts; therefore damage to the rolling stock seldom results.

But these very strong parts are also very rigid, so that the dynamic forces not taken up by the springs are destroyed suddenly. Everything movable in the train is consequently hurled violently forwards, and the staff more especially is exposed to serious risk.

Such forward shocks must in our opinion at any cost be avoided, either by quick transmission of the brake action, or by increasing the dynamic resistance of the buffers. We think that it will always be an advantage to combine both these means, and that only the use of friction gear will enable buffers to satisfy the existing requirements when long goods trains are braked (1).

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(1) See " Note on buffers ", by J. Doyen in the *Bulletin of the Railway Congress* for December 1906, p. 1771.

[656 .212]

THE THEORY OF THE DESIGN OF RAILWAY FREIGHT TERMINALS,

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Presented January 23, 1907.

Figs. 1 to 6, pp. 604 to 616.

(*Journal of the Western Society of Engineers.*)

The demands upon a freight terminal yard.

The general purpose of legitimate railway construction is to provide facilities for the forward movement of traffic. In a freight terminal yard, this means the facilities to receive incoming freight trains, rearrange the individual cars and their contents in proper order for going forward, and to deliver the cars so arranged to road crews or switching crews for the proper forward movement.

The movement through a terminal yard to accomplish this purpose, is more or less similar for all classes of business, and advisable differences in the outline and dimensions of yards are for the purpose of expediting and economizing the operations to suit these varying classes of business; in nearly all cases, however, the yard arrangement desirable for effective operation is adversely affected by local conditions, such as the lay of the ground, the position of connecting railway lines, and permanent construction and allied considerations, to all of which the yard design must be adapted.

The design of a terminal yard must be adapted to rapid and economical, as well as to the proper, movement of cars for the forwarding of traffic; such a statement seems so clearly a vital consideration as to be a truism; nevertheless, these requirements of a

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(1) This article is respectfully submitted at the request of members of the Western Society of Engineers, with whom the writer has been associated in work, by permission of the engineer of construction of the Missouri Pacific System, and the chief engineer of the Lake Shore & Michigan Southern Railway, in the service of which companies this subject has been studied.

terminal yard are not fulfilled in the majority of terminals examined by the writer. The time of ordinary freight through a terminal yard should not and need not exceed four hours, from the time of receipt until departure; expedited freight can readily be put through in one hour's time; and freight that must be transferred, rearranged, shifted or otherwise given extra handling, should not be detained to exceed twelve hours. These requirements as to time are not only essential for economy, but for the conditions of competition as well.

The cost of moving freight through terminals can be held down to less than 15 cents per car for all operating charges including breakage of cars. The actual cost per car on the same basis in the average yard probably approximates 30 cents. The difference between these two figures is the saving that efficient design of trackage, grades and facilities effects.

There are a number of auxiliary demands upon freight yards. Partial carload lots of freight brought in by different trains and from different towns, should be consolidated to the full economical capacity of individual cars, so no unnecessary cars will be hauled forward.

Cars of foreign lines, for the use of which to the destination of their loads the *per diem* charges, or penalty charges (assessable under the general car service rules of this country) will aggregate or exceed the cost of labor for transferring to a home car, should usually be transferred to home cars at the receiving terminal, unless the car situation prevents.

So-called way-freight should be assembled from the different odd cars that bring it, at the transfer platform of the last division terminal prior to delivery, and there loaded in station order in cars, to permit economical and convenient unloading and minimize losses.

Cars of perishable freight require icing; cars of stock require water, feed and often rest and sometimes transfer to different types or ownership of cars. Cars of potatoes and certain other perishable shipments must be housed at times in the winter to prevent freezing.

With all these demands in view, the amount of traffic to be handled daily must be considered in deciding the general type of yard to design.

The general types of terminal yards.

The bulk of work in a freight terminal yard is the separating or classifying of cars. This is accomplished by switch engine service in some one of several ways. The ordinary method of pushing and pulling, or as it is more commonly known, the " kicking " method, is the best known. It is adaptable to almost any lay of ground, costs the least in first construction and within the limits of effectiveness, when well handled, a yard so designed does excellent work. Only a limited number of cars can be handled by this method, and these at a higher cost of operation and higher cost for breakage of merchandise and excessive damage to equipment.

The " poling " method has been used as an improvement on the " kicking " method, to lessen the damage claims, and damage to cars, as well as to increase the capacity of the yards. It requires an extra track parallel with the ladder to which the body tracks of the yard connect, and requires these two tracks to be tangent or nearly so; its first cost is accordingly somewhat greater than that of a kicking yard, and it demands more favorable ground than the kicking yard. It will handle about 100 per cent more traffic than a kicking yard, at a somewhat smaller expense per car, *if well handled.* This last clause must be clearly remembered, in judging of the success or failure of a given poling yard. The almost irresistable tendency is to attempt to handle poling yards with an insufficient force of switchmen, and the resulting breakage of cars and contents has reacted against this general method of switching.

The application of the power of gravity to give cars the forward movement to carry them into their respective classification tracks, has developed sufficiently, so that it may be confidently stated that this method is the best and the only one, so far attempted, which will handle heavy business speedily, economically and satisfactorily. The past decade has seen the construction of yards where the entire motive force for giving cars the initial impulse forward for quick movement into their respective tracks, and the continuing impulse to carry them well ahead on these same tracks, has been secured by a clever adaptation of the force of gravity. In speaking of these latter years of progress, there is no desire to discredit earlier efforts.

Credible advice has come to the writer of excellent working gravity yards constructed in the early '70's, at Hoboken, New Jersey, for handling tidewater coal for the Lackawanna line, and a later and successful use of gravity at the Honey Pot yard of the Pennsylvania Railroad, Sunbury, Pennsylvania, for making up coal trains. The conditions at each of these points are so widely different from those of the typical freight terminal, that the only application pertinent to an article that should be brief as possible, is their corroboration of the usefulness of the general principles of gravity. Full statistics of the bulk of the yards of this country can be found in the interesting article by Mr. W. C. Cushing, chief engineer maintenance of way, Southwest System, Pennsylvania lines, upon the subject of yard design, published during May, 1905, in various magazines.

The theory of design of a freight terminal.

There may be said to be four principal handlings of freight cars, and one auxiliary handling of a portion of them, involved in the movement of all traffic through a freight terminal; the occasional solid train that goes through with no change in its make up except to change engines, cabin cars and crews being an exception. These handlings are :

1° The receiving of incoming trains and the work incidental thereto;

2° The separating or classifying of cars, more commonly known as " breaking up " trains;

3° The grouping into train order for advance movement, of the separated or classified cars, commonly known as " making up " trains;

4° The forwarding of trains, and the work incidental thereto.

The auxiliary work is that already advorted to, *viz.* : the rearrangement, consolidation and transfer of freight for reasons of economy, safety, or because of the need of repairing the cars; the icing of perishable freight, or the feed, water and rest needed by stock. For these operations, facilities are needed as follows :

The receiving yard.

For receiving the incoming trains, a so-called " receiving yard " is needed. This yard should have tracks of a sufficient length to admit the maximum length trains that can be anticipated, witout doubling in. For this estimate, a car's length is assumed at 40 feet, and engine's length at 75 feet and a caboose to suit the standard of the railway; in addition, there should be provided space for a double header engine, and several 100 feet leeway for inexact stopping of trains. As there will be many short trains, these long tracks should be provided with a reasonable proportion of crossovers to thoroughfares so that a short train will not block the entire length of a track for a maximum length train. Also, as a number of trains have cars of perishable or live freight directly behind the engine, trackage outlet independent of the regular outlet of the receiving yard, should be provided to afford a direct and immediate movement to the icing plant or stockyard, so that the road engine can quickly take this high grade freight to these points.

The time of a train in a receiving yard under average conditions should not exceed one hour, for the purpose of cutting off the road engine and the caboose, the inspection of cars for defects, and the coupling on of the switch engine in readiness to commence breaking up the train. This hour of time can very wisely be used for making the light repairs to the cars needing such, and as a usual thing, about one-half of the defective cars in certain large yards are repaired during this period of inspection. This is accomplished by stationing a squad of car repairers at intervals along the track the train is entering, with a few tools and supplies. This work can be done with the tracks on 13-foot centers, but where there is space available, 14-foot centers are preferable.

The number of tracks in such a yard should be sufficient to hold the accumulation that may result from any likely derailment in the advance movement through the general yard system, or congestion from other causes.

An important and very necessary adjunct to a receiving yard, is the trackage for that ever-present evil of freight traffic, the " hold " business. The are always cars without way bills, cars of unconsigned lumber and unconsigned coal, to be held for billing at any terminal; these cars should never be allowed to block a receiving yard. Their forward movement is ordered day by day, a car or more here, and a car or more there, from the strings of cars on the hold tracks. It is manifestly bad operating policy to classify an entire string of cars either by gravity over a hump, or by poling to secure an occasional car for which billing has come; it is also bad policy do dig out these occasional cars from the long strings of cars by the push and pull method. Accordingly, there should be placed alongside the receiving yard, a sufficient number of moderate length " hold " tracks, which can be switched by the push and pull method; these tracks should be under control by the most generous proportion of drill tracks of the entire yard system. The writer makes it a practice for the usual coal hold yards, to equip each four body tracks with an independent ladder drill track at each end. There will, of course, come times when a sufficient number of billing orders arrive, to justify classifying an entire string of cars from a given track; the proper trackage for such a contingency should be provided.

The separating or classifying yard.

When solid trains of through freight come into a yard, they can go onward as received after inspection, change of crews and incidental work, without being broken up. For this class of trains, a by-pass line from the receiving yard to the forwarding yard unobstructed by the usual yard work, should be provided. Nearly all trains, however, contain cars of local freight for the particular division point where the yard is located, or of interchange freight for other railway lines; and cars of company supplies, bad order cars and improperly loaded cars are usual. Different ruling grades or motive power assignment on the next division, may require the train lightened or filled out. The yard may also be a junction for diverging lines of the railway, and trains will usually have freight for each line. For these reasons, the cars of an incoming train must be separated, assembling on one track the cars for a given destination or class of yard work, on another track, cars for another, and so on until all cars for a similar destination are together.

For this separation work, there is required such a number of tracks as the number of classifications suggest, after considering the influence of acceptable operating demands, the yard space available, the second switching needed and local conditions. It is very difficult to set a hard and fast rule as to number of tracks needed without a thorough knowledge of the situation at the proposed terminal, and it would render this article unduly tedious to set forth all the deductions from the various contingencies that may develop at different points. Briefly, it may be said that the separating yard should be designed so that, so far as possible, all the separating of different cuts of cars be accomplished when first dropping them into the separating yards, and at the outlet end of the separating yard, the work as far as possible, should be only that of bunching together these groups of cars from the different tracks into a train lot. In spite of the most favorable design, a certain amount of second switching at the outlet end of the separating yard is necessary to put cars into train order. Where this amount is small, it can be accomplished by the push and pull method by providing the outlet end of the body tracks with a good ladder drill system, so that engines can work simultaneously without delaying each other. If this "tail switching" aggregates a considerable amount of the traffic or must be done quickly, the cars should be taken to a second separating yard, more properly called a "grouping" yard, or classifying yard, where the grouping into train order can be done without interfering with the functions of the main separating yard. This latter grouping yard is particularly needed where there is a large proportion of fast freight to be handled. The length of the individual tracks in a separating yard is usually made equivalent to a maximum train length, and excellent operating men urge this as advisable at the present day. The writer believes that in nearly all cases, such tracks should be of about 60 per cent the length of maximum trains, except where traffic is so regular and heavy that a maximum train length of cars which require no grouping into train order, can be expected to accumulate within the time limits that such cars can properly be held before forwarding. This belief is based upon the unfavorable working of long tracks in existing yards examined by the writer, and upon the following theory : a classifying or separating yard is not a storage yard, nor, should it be so used in any part, as such use blocks the particular tracks from receiving additional cars, as the work of separation proceeds. That portion of the traffic that is held for bills, or is unconsigned should be moved to a "hold" yard, as earlier outlined. All other freight should be separated, made up into trains and forwarded as a continuous movement, for the plain business reason involved; these reasons are, the better use of the equipment, the speedier forwarding of freight, and the smaller force of yard men thereby required. A train is ordinarily made up by coupling together the accumulation of cars on a number of the tracks of the separating yards, until a train lot is assembled. If it is a fast freight train, the high-class freight that is accumulated on the different tracks is coupled together and enough cars of ordinary freight put on at the rear end to fill out the train to the desired tonnage; the road crew couples on and the train starts on its road movement.

This process is continually recurring. By so handling the train make-up work, there is a minimum delay to the cars and a smaller force of engines and men is needed, than if the work were concentrated after certain intervals of waiting for train lots of a single character to accumulate. Granting that this general statement of conditions applies to a given freight terminal, it is clear that no good end would be served by constructing long tracks in the particular separating yards, and it is likewise clear that much more rapid coupling together of accumulations of cars on each of a number of tracks, can be done if those tracks are of moderate length than if they are of the length of a maximum train. Besides, it is, of course, less costly to construct and maintain a yard of moderate length separating tracks, than of longer ones, whether the yard be on a level grade or a gravity yard; similarly, it is clear that it is less costly to separate trains into a yard of short tracks than of long ones.

In starting this discussion of the length of the tracks, the writer said that the statements to follow applied "except where traffic is so regular and heavy that a maximum train length of cars which require no grouping into train order, can be expected to accumulate within the time limits that such cars can properly be held before forwarding." This proviso should be distinctly considered, for this feature has often proved to be a stumbling block in a yard design.

There are only a few railways in this country whose business at the largest gateways is so heavy as to justify the adoption of the above exceptions. At the St. Louis gateway for instance, the Gould System of Railways handle about 66 per cent of the total aggregate business of the 23 railways entering that important gateway; nevertheless, the rapid forwarding of cars demanded by the conditions of competition, absolutely forbade any construction of long tracks in the separating yards to hold accumulations of cars for the same destination. Accordingly, the separating tracks at Dupo were established at 35 car lengths each, basing this upon a train length of 60 cars as the maximum advisable for belt line movement. At Buffalo, the slow freight of the Vanderbilt System accumulates rapidly in train lots, with practically no train order work needed; accordingly, certain tracks were provided to hold 100 cards each in the separating yards; these are supplemented by shorter tracks for fast freight business.

At Pittsburgh, traffic probably accumulates fast enough to justify such maximum length tracks; also, at the heaviest coal receiving points on the eastern lines of the Pennsylvania Railroad and the New York Central System, and possibly other lines, and at the principal tidewater points the same is undoubtedly true.

The tail switching at the outlet end of the separating yards has already been mentioned. This second switching is very much of an evil at best, and to minimize it, the outlet end should be arranged for the most advantageous kicking switching. The ladders so provided must give perfectly movement for simultaneous drilling.

The forwarding yard.

When a train is made up, it is taken to the forwarding yard where the air brakes are tested and coupled together, the caboose and road engine coupled on, the starting order or signal given and it moves forward on its way to destination. For this purpose are required tracks to hold the maximum lengths of made up trains; these tracks in turn should have crossovers to hold two short trains on a single track. Lines of compressed air pipe should be provided. The caboose tracks should be close to one end of this yard. Some railways prefer that the cabooses be kept near the outgoing end of this yard, so the caboose can be put on by gravity or otherwise as the train pulls out; other railways insist that the cabooses be put on the train before it starts. The writer sees no marked preference either way, if skill is used in designing the tracks. Thoroughfare tracks must be provided in sufficient number so that there can be no friction or delay in the pulling of made up trains from the separating yards into the forwarding yard, and in the caboose and road engine movements.

GENERAL DETAILS.

The types of frogs advisable.

The angle of frogs generally used in yard tracks have been one in six and one in seven. When engines and cars were of comparatively light weight and the purchase of land limited to the smallest tracts that would admit of a working arrangement, there was justification for such angles. Since the Motive Power Departments began flanging all driver wheels, and the weight of engines has increased so much, the sharp leads required by these short angle frogs have been expensive and difficult to maintain, and derailments much increased. This is generally recognized, and easier frog angles are being favored in recent years. In a terminal yard where switching is constant, no frog of lighter angle than No. 8 should be permitted, and this frog only in the portions where the work is done exclusively by yard switch engines. The yard and road engines of the present day will frequently derail themselves on a No. 8 lead in perfect condition. In the receiving and forwarding yards, where the road engines must move, and in the approaches to the humps of gravity yards, the frogs should be No. 9 at the sharpest and No. 10 if practicable. The enormous engines used for hump engines are very destructive of switch leads, and will derail themselves frequently on sharp leads. In the ladder leads of separation yards operated by gravity, the curvature of the switch leads must not be such as to bind the cars running around them; a No. 8 frog is the sharpest justifiable, and No. 9 the preferable angle at this point. These general rules as to frog angles may seem hard to follow on a given strip of land; but the evil of their disregard is certain. The writer makes it a practice to make the diverging angle of the body track as large as possible and carry the curve beyond the frog to make up the total central angle. In portions of a yard where there is very little switching, this method can be varied to permit alternate body tracks to act as a subordinate ladder for another body track, thus placing upon the main ladder only one-half the switch leads. This device must not be used in ladders where there is considerable switching, as its use involves delay in work and danger to the switchmen, and is certain to cause side stripping of cars occasionally.

Ladder leads.

Ladder leads should be adapted to the needs and use of the body tracks they control. They should be as short as business permits, and the body tracks that one ladder cannot well control should be coupled to another ladder. It is generally conceded by operating men that a single switch engine cannot economically switch more than eight tracks. This rule would make that number the maximum number of body tracks to couple into a single drill track. Figure 2 shows a combination of three units of eight tracks per ladder illustrating the simplest type of classifying yards. In such an arrangement thre engines could be switching continually without friction. Before accepting the above rule as conclusive in a given case, the number of separations required to put a train into proper order for forward movement must be considered. If there are more than six groupings required, and only eight tracks provided, a corresponding amount of temporary bunching and re-switching will be necessary. Conditions often require fifteen to twenty classifications to make up cars into train order, and these conditions must be met satisfactorily, if economical and efficient work is to be secured. At such points, if the separation work is to be handled by the push and pull method, two drilling leads can be designed with half the total number of classification tracks needed, coupled to each ladder; between these two drill tracks should be placed two receiving tracks common to each drill. Upon these special receiving tracks can be placed the overflow groups from one side that are to be later grouped on the other side and vice versa. This, of course, means re-switching, but there is no better solution if this difficulty, and the usual custom is more disadvantageous. Figure 3 indicates a combination of two units of eight tracks per ladder with the two common tracks between for receiving the overflow cars from either side to meet such conditions.

In the hump yard system, the above rules do not obtain in the gravity portion of the separating yard. Here the motive force that starts each car and moves it forward into and partly through the separating yard, is gravity only; the only work required of the switch engine to effect the separation of the cars is to push a train up to and over the apex of the hump. If the track arrangement and adjustment of gravity ratios beyond the apex are properly designed, the cars will run over a single track throat into the respective tracks of the separating yard faster than it is physically possible to bring them to the apex by the most advantageous track arrangement. Accordingly, there is no object in providing more than a single track throat to such a yard. The usual difficulties with gravity separation yards are due to improper adaptation of gravity, sharp switch leads und unnecessarily curved ladder leads, which cause the cars to bind and either lag or entirely stop before reaching the right point : also excessively long ladders which call for high humps, slower movement of trains, greater forces of riders and other evils. The question of gravity ratios will be taken up later in this article. The track arrangement should be based upon coupling to a single ladder not more than ten tracks in the very largest yard, and not more than six tracks, if possible, in other yards; if a given hump yard is to have twenty-four tracks, four ladders each with six tracks coupled would be required. If thirty tracks are needed, it would be better that eight tracks each be coupled to two ladders and seven each to the other two ladders, as it is seldom advisable to put more than four ladders in a yard, owing to the extra curvature involved in the tracks from the fifth and sixth ladders. This arrangement of four ladders is shown in figure 4 in comparison with two ladders for the same number of body tracks, and a profile for each, all drawn to the same scale and for similar operating conditions. The advantage of the four ladder scheme is manifest.

In a hump yard, the ladder switches at the entrances of the body tracks can be operated, either automatically from a tower at the throat of the yard, or by individual switch tenders. Excellent electro-pneumatic systems for handling these switches are used at many of the larger yards, satisfactorily to the operating officers. On the other hand, the switch tenders are used at other yards with even greater satisfaction. The electro-pneumatic method is the more economical of the two, but has the disadvantage of being slower in operation.

Pull up engine or car.

In a busy yard there is distinct economy in providing an engine or trolley car to bring the switchman back up to the hump after riding a car to place. Usually some old light engine is assigned to this work. Gasoline cars have been tried, but are so continually breaking down as to be of little value. A trolley car is probably much the cheapest device for this work. For the movement of these cars, a separate track should be provided at about midway of the yard; if the yard is a large one, two such tracks may be advisable, with two trolley cars or engines.

The track scale.

There are few questions in yard design more annoying than the proper location for the track scale. At terminal points, where large yards are needed, there is usually a considerable proportion of the total business to be weighed. If this percentage justifies it, the scales can be placed on the hump alongside of and parallel with the regular entrance track to the separating yard, so that the trains containing weigh cars can pass over the scale as they enter the yard. This is the quickest method of weighing. It is however, a distinct misfortune to all other traffic to place the scales on the hump, as the adjustment of gravity ratios to properly move cars for weighing, is not the most advantageous for other freight. Cars can be weighed satisfactorily to the weighing associations, while running free, at the rate of abopt four a minute. If there was a continuous supply of cars available, and there were no delays in moving them forward to the hump, this would mean the weighing of 240 cars per hour, or in the ten hours of the days work, 2,400 cars, and in the ten hours of night work, about 25 per cent less, or a total of 4,200 cars per day. As a fact, however, the interruptions to work are so continual as to cut the daily weighing down to about one-third of this amount. On the other hand, the grades that are suitable for a plain throat track, free from scales, will permit the classification of cars faster than it is possible to bring them up the hump. The writer has seen eleven cars per minute,

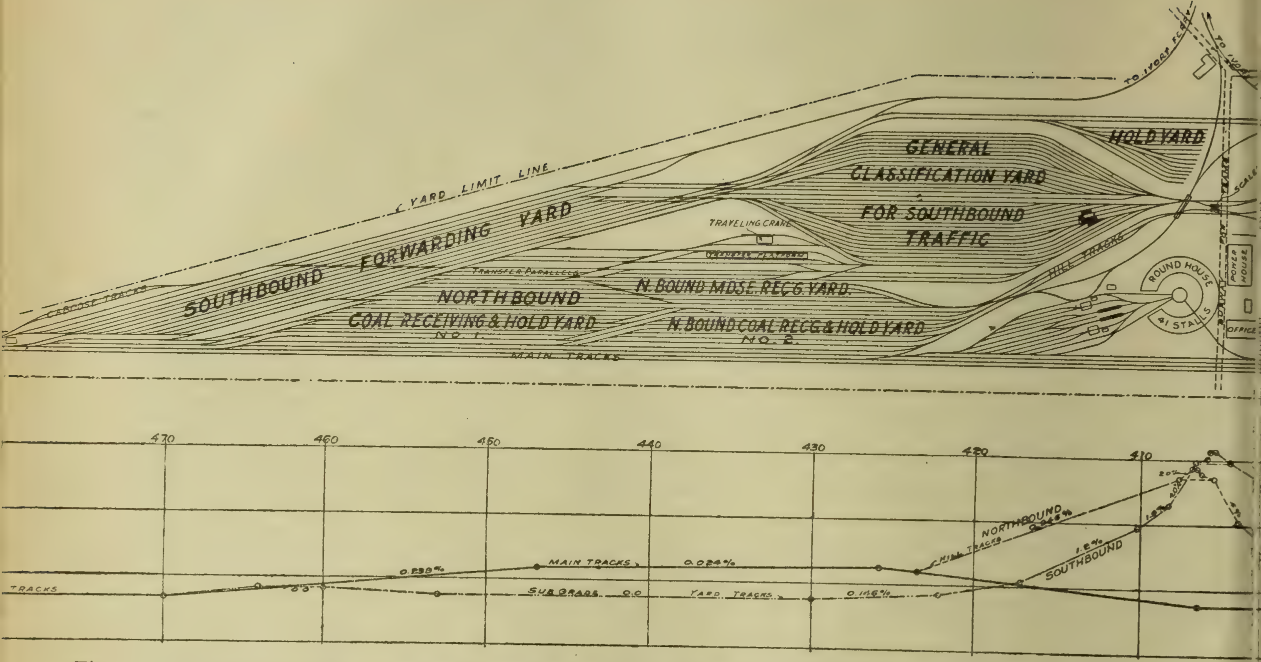
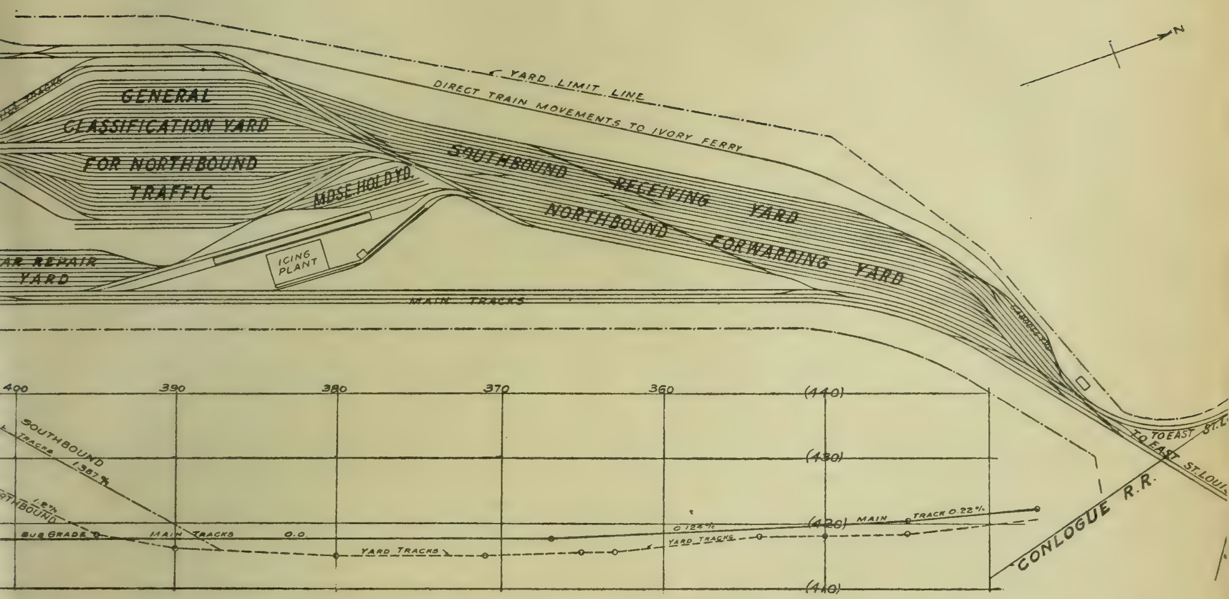


Fig. 1. — Condensed outline of proposed terminal yard for East St. Louis territory, Missouri Pacific System, located at

classified over a well arranged hump until the car supply gave out, and from average results from several yards known to the writer, he thinkd it safe to count on an average of 3,000 cars per day of twenty hours as readily possible, even under adverse conditions, with an ordinary force of riders, and no special effort. These conditions urge one to attempt to locate the scales elsewhere than on the hump.

In developing plans to be submitted for the Buffalo Terminal Yards of the New York Central Lines, to be located at Gardenville, just south-east of Buffalo, New York, where the proportion of cars to be weighed was unusually small, the following scheme was developed; for heavy runs of weigh cars, a scale was placed at the mid-length of an independent track, extending outside of and alongside the general separation yard from its outlet backward to the receiving yard. The weigh cars were to collect on a particular track in the separating yard up to the capacity of an engine to handle readily. They are then pulled out from the separating yard, and pushed backward to the scale track, and weighed as they move over the scale towards the receiving yards. When weighed, they are pushed to the entrance to the hump, ready for re-classification for destination. The easiest way to re-classify is, of course, by gravity, and the cars are in the correct place for moving over the hump for this purpose. The backup movement involved in this scheme of weighing is unfortunate, but is a much less evil than is involved in placing the scale on the hump. For comparatively light business, a distinct improvement in the above scheme for weighing, was suggested for the Buffalo Terminal, by Mr. R. O. Rote, principal



ıpo, Illinois. — Planned, April 1905. — Under construction, September 1905 to date. — Not entirely completed.

assistant engineer, Lake Shore & Michigan Southern Railway. The scale was placed at the mid-length of the outside body track of the general separating yard, and the particular gravity ladder running from the throat of the yard to this track was connected to a thoroughfare track by a trailing switch. After the upper end of the gravity scale track was filled from the scales to this trailing switch, a yard engine ran through to the cars, pushed them over the scales, then reversed, pulling them oback, viâ the outside thoroughfare around the hump to the receiving yard, and reversing again, pushed them over the hump. This movement interferes slightly with yard operation but can usually be performed to fit in with other work smoothly, and for such amounts of business as it can handle, it is distinctly the best arrangement known to the writer.

The adjustment of gravity ratios, in a gravity terminal yard.

The movement of a train of cars up and over a gravity hump, is for the purpose of placing the cars at such a height as to secure, by the aid of gravity, for each cut of cars, a quick start forward as the cut passes beyond the apex of the hump, and momentum sufficient to carry the cut onward through the arrangement of switches into the proper track in the classifying yard, and onward through this track until the lessened grade of the body of the classifying yard causes the cut of cars to stop from the combined friction of the car journals, the resistance due to low joints, poor line and worn rail usual in yard tracks.

Analyzing this movement in detail, it can be resolved into the following elements, each of which is essential and each of which calls for the proper adjustment of gradient and alignment in yard design.

The initial start of a cut of cars is caused by the grade placed just beyond the summit of the hump; this start corresponds to the thrust given cars by the boom of the poling car in a poling yard or to the " kick " given by the switch engine in the ordinary " kicking " yard. This starting grade is usually called the " momentum " grade; and as this entrance point controls all movements into the classification yard, any delay at this point would to that extent lessen the operating capacity of the yard, regardless of favorable arrangements elsewhere. Furthermore, if the momentum imparted is not sufficient to carry the car through the distance it must run at the best rate of speed consistent with safe operation, the yard is again limited in capacity. Accordingly, the grade must be sufficient to start the cut of cars quickly forward, and it must impart sufficient momentum to keep the car going. This momentum should theoretically be assisted by sufficient grade beyond the limits of the hump grade to enable the car to run over the switches at the throat of the yard and in the ladder leads and around the curves at these points, until the cut reaches the proper destination track of the yard at the uniform speed, but not to increase the rate of speed. This grade, properly called the " continuing " grade, is an important feature, as the lagging of cars on the ladder leads, resulting from insufficient grade, would limit to that extent the operating capacity of the yards, and in most hards does do so. Other considerations, however, affect a decision as to this advisable gradient, and compel the proper rate to be exceeded to meet difficulties of operation. A hard moving car, although given the proper momentum at the hump, will lag on the ladders and delay other cars following it; and unless the grade of the ladders is sufficient to quickly start forward these delayed cars when the hard moving car has entered its destination track and cleared the ladder, the slow movement of one car will be continued to a serious degree in the following cars. Accordingly, this continuing grade must be steepened for this purpose so the classifying yard, so that cars may not be stopped too early.

Once in on the destination track of the separating yard, the car should have sufficient momentum to carry it well onward toward the out-going end; and in this latter portion, it should be stopped by the friction of its own movement by lessening or discontinuing the grades. To assist the car in keeping its momentum in the earlier part of this run through the yard, a few hundred feet of grade equal to the friction of the car journals andt rack condition is provided. This grade is the " drifting " grade. The " checking " grade that follows is very largely determined by the length of the individual tracks of the classifying yard, so that cars maye not be stopped too early.

Application of the theory of grades.

In deciding what rates of descent will, by the force of gravity, cause the cars to move as above outlined, a number of conditions affecting operation must be considered. In addition to the theoretical grade required to overcome the ordinary rolling friction of cars on tangent, must be added compensation for curvature of switch leads, compensation for the friction due to low joints, worn rails, and inferior line unavoidable in yards; also the extra force of wind against cars on the high portion of the yard must be provided for, and the hump, in addition to all these considerations, the grade must be adjusted to give a quick start forward.

Also, there must be considered the effect of low temperatures of the winter season on the car journals, and the still more inconvenient feature introduced by the occasional hard running car; freight equipment is subject to hard usage and comparatively scant care, and some cars require more grade to run moderately than others do to run freely. As the slow running car must not be allowed te delay movements, the gradients must be adapted to its condition, and the more freely running cars controlled by the brakes. Besides, empty cars start more slowly, run harder and are more retarded by wind pressure, than loaded cars.

Accordingly, in selecting the combination of grades for a given yard, after ascertaining the classes of traffic to be handled, and the special handling involved, the final decision as to the gravity ratios is based on those that will satisfactorily move the hard running cars under adverse conditions of the weather, wind, and track; the free running car, if unbraked, would gain a higher speed on such grades than advisable for safe operation, and the brakes are depended upon for this checking.

In determining the aggretate effect of the elements of compensation, dependence must be placed upon the results of the use of the existing yards of the gravity type.

From the day of the early gravity yard of the Lackawanna Railroad at Hoboken in successful operation in the early '70's, up to the present time, the trying of different gradients has continued, and few engineers are yet convinced as to the proper adjustment. The momentum grades that have been used, vary from 0·75 to 7 per cent for a distance of one hundred feet or more; ladder grades have varied from 0·5 to 2 per cent; drifting grades have been the usual theoretical rate of 0·4 to 0·5 per cent, and the checking grade has varied from a level to 0·3 per cent. It is said to be the custom of some companies to put up a steeper momentum grade in winter to overcome the effect of the greater friction of the car journals; this has been done at Pitcairn and Altoona, Pennsylvania, but the faster movement of cars caused thereby was so desirable that the winter grades were not cut down when warm weather came, and, the writer understands they continue so today.

With all these considerations must be balanced the danger of smashing cars, due to possible excessive gradients and the failure of brakes or their improper application. It must be recognized, though, from the smashing of cars in yards of the lightest gradients in use, when brakes fail, that it is impossible to design a gravity yard even at great sacrifice of efficiency in operation, that will prevent damage to the unbraked car.

Accordingly, the brakes must be depended upon to control the cars when needed, and the car without a brake, or with a defective brake, must be either herded out for repairs or dropped down into the classifying yard, coupled to the next car for weeding out through the outlet end. As a matter of fact, bad order in hand-brakes is quickly detected in the inspection of the train in the receiving yard and usually remedied at once, and little breakage results in a well handled yard for bad order brakes.

After consideration of these matters and examination of the actual working, day and night, good weather and bad, of the principal gravity yards of this country, the writer respectfully recommends as the proper grades the following ratios upon which was based the combination of grades for the Dupo yards of the Gould System :

Northern climate.	**Southern climate.**
Point on gravity system, momentum grade (with no scale on hump tracks).	
For loaded cars :	
200 feet of 3·0 per cent grade.	200 feet of 2·5 per cent grade.
For empty cars :	
200 feet of 4·0 per cent grade.	200 feet of 3·0 per cent grade.
(1) Momentum grade with track scale on hump track :	
25 feet effective 4 per cent grade, followed by scale on 1 per cent grade, followed by easy vertical curve, say, 50 feet in length, followed by 200 feet of 3·0 per cent grade for loaded cars, or 200 feet of 4·0 per cent for empty cars.	25 feet effective 4 per cent grade, followed by scale on 1 per cent grade, followed by easy vertical curve, say, 50 feet in length, followed by 200 feet of 2·5 per cent grade for loaded cars, or 200 feet of 3·0 per cent for empty cars.
Ladder grade for loaded cars :	
0·9 per cent throughout.	0·7 per cent throughout.
For empty cars :	
1·2 per cent throughout.	1·0 per cent throughout.
Continuing grade through yard	
For loaded cars :	
0·3 per cent.	0·2 per cent.
For empty cars :	
0·4 per cent.	0·3 per cent.
Checking grade :	
Between 0·0 and 0·2, dependent upon length of tracks.	

In case curvature exceeding eight degrees per hundred feet is used in any switch leads from the hump downward, compensate for the excess over eight degrees beyond the grades above suggested at the rate of 0·06 per cent per degree of central angle per station at the point ; and in case of any curvature in the ladder track or body tracks of the separating yards, it should be compensated for at the rate of 0·04 per cent per degree of central angle per station at the point. Instead of the usual method of compensation, the friction of curvature of switch leads can be provided for by dropping the body tracks downward by a stiff vertical curve just beyond the end of the frog.

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(1) When scales are required on the hump, put two tracks over the hump, one for the plain track movement, one for cars to be weighed, combining the grades at a point reaching the entrance to the yard.

The recommendation of compensation for curvature is the result of observation of the lagging of cars in yards where compensation has been omitted. The rate of compensation is placed higher than for main track because of the poorer conditions that prevail in yard track.

No less important than the adoption of proper ratios of grade is the placing of the apex of the hump as close as possible to the entrance of the yard; so vital is this consideration that a yard, correct in all other respects, will be a failure if this point is ignored.

These conclusions are based upon examination of the following yards, whose important grade characteristics are mentioned :

RAILWAY.	LOCATION.	YARD.	GRAVITY HUMP.	RATIOS LADDER.
Chicago Union Transfer Railway.	Clearing, Cook Co., Ill.	Both ways.	200 feet 4·0 p. c.	0·9 p. c.
Pittsburgh, Fort Wayne & Chicago Railway	55th street, Chicago . .	Eastbound.	150 — 3·0 —	0·5 —
		Westbound.	150 — 3·0 —	0·5 —
Pittsburgh, Cincinnati, Chicago & St. Louis Railway	Logansport, Ind. . . .	Eastbound.	(1) 125 — 2·4 —	0·5 —
		Westbound.	(1) 250 — 1·45 —	0·43 —
Lake Shore & Michigan Southern Railway.	Elkhart Ind.	Eastbound.	200 — 4·0 —	1·0 —
		Westbound.	200 — 4·0 —	1·0 —
	Collinwood, Ohio . . .	Eastbound.	200 — 4·0 —	1·0 —
		Westbound.	200 — 4·0 —	1·0 —
Pittsburgh, Fort Wayne & Chicago Railway	Conway, Penna. . . .	Eastbound.	210 — 3·0 —	1·0 —
		Westbound.	480 — 1·8 —	10·6 —
Pennsylvania Railroad	Altoona, Penna. . . .	Eastbound.	185 — 4·5 —	0·9 —
		Westbound.	125 — 4·0 —	0·92 —
			100 — 2·5 —	1·3 —
Pittsburgh, Cincinnati, Chicago & St. Louis Railway	Scully, Penna.	One only.	100 — 2·5 —	1·3 —
Pennsylvania Railroad	Harrisburg, Penna. .	No. 4 Westbound.	150 — 3·6 —	1·2 —
	Fairview, Penna. . .	Eastbound.	150 — 3·6 —	1·2 —
		Westbound.	125 — 5·5 —	1·0 —
	Marysville, Penna. . .	Eastbound.	250 — 2·5 —	1·2 —
		Westbound.	225 — 2·0 —	1·2 —
	Alexandria, Va. . . .	Eastbound.	100 — 2·5 —	1·0 —
		Westbound.	100 — 2·5 —	1·0 —
	Greenville, N. J. . . .	Tidewatter.	50 — 2·5 —	1·0 —

(1) Combinaison of various grades, averaging about this ratio.

Of the above yards, the most satisfactory in operation are the Elkhart yards and the Collinwood yards of the Lake Shore & Michigan Southern Railway, the Harrisburg No. 4, and the Enola yard of the Pennsylvania Railroad. Each of these have momentum grades of 3·5 to 5·5 per cent and are stated to be entirely satisfactory by the local, division and general officers. In making this statement it is only fair to say that this conclusion was formed by the writer prior to his entering the service of the Lake Shore & Michigan Southern Railway.

The Clearing yard, more generally known as the " Stickney " yard, and the Alexandria yard, were not in operation when examined by the writer.

There are other extensive and well tried yards in the United States, which the writer has not had opportunity to examine.

The New York Central's yards at De Witt and Albany, the Pittsburgh, Cincinnati, Chicago & St. Louis Railway yards at Columbus, Ohio, and the Pitcairn yards, near Pittsburgh, and the Hazelton yards of the Pittsburg & Lake Erie Railroad, near Youngstown, Ohio, have not been personally examined, although each of them is an important point and would afford much information. Verbal advices from the operating or engineering authorities at each of these points, however, have been received which confirm the conclusions shown in the preceding tabulation of advisable grades.

The general relation of the component parts of a yard system.

It need hardly be said that the relative physical position of the receiving yard, the separating yard and the forwarding yard should be such that the movement of cars will be forward toward destination. This calls for a tract of land from one to four or five miles in length, which is often impracticable to secure at a justifiable price. This rule can be violated apparently with impunity, and still by good design in the yard arrangement, not appreciably delay traffic; just where to draw the line in a dicision is very hard to say. For instance, the New Orleans Terminal Yard of the Illinois Central Railroad at Harahan, Louisiana, is placed substantially at right angles to the main track of the Illinois Central and Yazoo and Mississippi Valley Railroads. It is stated by the present general officers of those companies to be satisfactory in operation in spite of the fact that when a train has gone through the yard it is physically no farther along toward destination than when it entered the yard. At Collinwood, Ohio, are the two gravity yards of the Lake Shore & Michigan Southern Railway, one for east bound traffic, one for west bound traffic. Both yards are constructed for moving cars directly te the west owing to the natural slope of the original surface being descendent to thewest. No appreciable delay is experienced in handling the heavy east bound traffic in a westward yard movement at this point.

In the smaller yards, operated by the push and pull method, the local conditions almost absolutely control the relative location of the different parts and no other general rule can be given than the one above, and the discussion under the sub-heading of " ladder leads." The skill with which the general principles of yard design are adapted to a given point, determines the efficiency of a yard. All the demands of a fairly busy point can be met by a yard of eight body tracks and the auxiliary facilities under good arrangement.

Figures 2 and 3 show the arrangement of drilling lead and body tracks of these simpler types of yards, to be embodied in the design of a small yard for a particular point. These give eight tracks as the advisable number on a single drill track. Such an arrangement makes one body track a receiving track, another body track the forwarding track upon which the new train is made up, and assigns the other six tracks for the classification work. No attempt has been made to more than show the units of the advisable arrange-

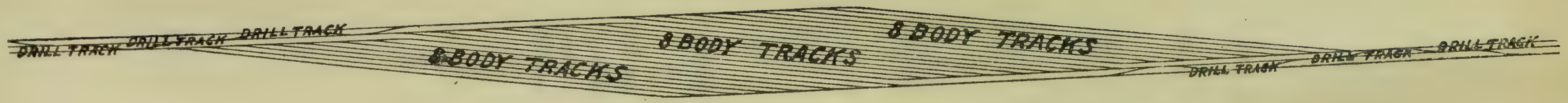


Fig. 2. — Outline of units of typical yard for switching by the usual push and pull method.
Eight body tracks per ladder adapted to points where six classifications will usually suffice in making up trains.

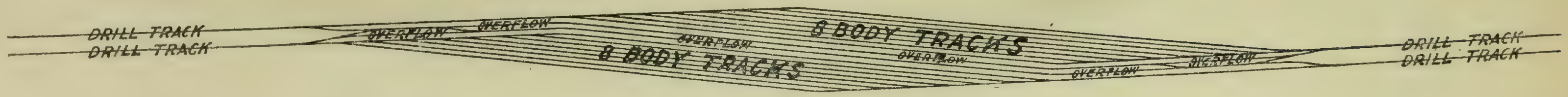


Fig. 3. — Outline of yard for switching by the usual push and pull method.
Eight body tracks per ladder adapted to points where business continually requires more than six classifications in making up trains.

ment for classifying; this work is the most important of the yard, and if it is well provided for, there need be no difficulty in adding the car repair tracks, caboose tracks and other facilities needed. The amount of elaboration of these units, the addition of other tracks at either end to act as receiving and forwarding tracks, and other increased construction, all depends on the amount of business anticipated.

The auxiliary facilities required in a terminal yard, and equipment for convenient working.

The special work to be done in terminal yards is more or less similar in all localities. It consists of items a follows :

The repair of cars found to be defective. This work may or may not require the contents of the car to be transferred. The proportion requiring transfer would probably not exceed one-quarter of the total number of bad order cars.

The adjustment of shifted loads. It is difficult to load and bind certain classes of freight to hold to position, and such loads, when shifted, must be replaced for safe forwarding. This is particularly true of lumber, which frequently shifts. It is not necessary to transfer to another car such loads, unless damage has resulted to the car. Shifted loads of lumber on plain flats can be squared up by pushing against the shifted lumber a "squaring car."

The rearranging of improperly loaded cars into proper cars.

The transferring of contents of cars, to save "per diem" or penalty.

The transferring of contents of cars, to utilize equipment to greater advantage.

The consolidating of partial car-load lots to secure greater tonnage.

The transferring of L. C. L. freight to suit destination.

The transferring of special products to permit of classification and distribution according to destination as thereby determined.

This work of transferring, rearranging, and consolidating freight is an attendant evil in all terminals; it cannot be overlooked except at distinct disadvantage. Properly handled, it favorably affects the tonnage showing, the time showing, and the economy of operation. For its convenience should be furnished a sufficient number of parallel tracks, with a covered transfer platform at some central point, and individual platforms also between each two tracks. The object of these platforms is to save spotting the cars and to permit free movements of truckmen up and down the lines of cars; the covered platform is to permit occasional storage of car contents temporarily in readiness for final reloading. At the end of the covered platform should be built sufficient warehousing to hold freight without bills, "over" freight, freight not completely loaded at the close of work at night, gang-planks, trucks, and for the conveniences for the truckmen, check clerks and bill clerks. A transfer crane is needed for lifting heavy loads for re-adjustment or transfer.

The icing plant.

During all the year in tropical or semi-tropical climates, and during the bulk of the year in cooler climates, perishable freight in transit needs re-icing. In some cases, this freight moves in solid train lots, but usually it comes mixed in with other cars or with other freight at the rear of the train to fill out the train loading. For solid trains the road crew should be able to take the train direct to the icing plant without stopping in or running through the receiving yard. For partial train lots, the movement must be over the hump of the separating yard, this being the quickest way of separating the cars; for partial train lots, with the perishable freight bunched behind the engine, direct and quick access from the outlet end of the receiving yard to the icing plant is essential, and in turn convenient outlet from the icing plant to the forwarding yard is needed. The icing plant itself must be equipped with a convenient machinery room for preparing the ice and with overhead runway platforms alongside the icing tracks to permit rapid work.

It is not wise to attempt the icing of more than twenty-five cars at a time on each track, owing to the melting of ice in long hauls in trucks. Accordingly, the ideal arrangement is for platforms one thousand feet long, with an equal length of icing track beyond each end, so a lot of twenty-five cars, iced can be moved on ahead, and a second lot be quickly brought up to the platforms from the rear.

The dimensions of the house itself are controlled by the numbers of tons storage capacity required. If icing tracks and platforms are needed on one side only, and the other side for filling the house in the winter, or loading cars for shipment to other points, a width of about 60 feet is advisable. If the house is to have icing tracks on each side, it should be of greater width, to secure proportionate storage capacity. Whatever the width may be, the house should be built in units or pockets that can be added to as greater capacity is required; the central unit of the house should be the machinery room where all the ice breaking is done, and, to and, from which all movement to the outside are made. Such an arrangement for working minimizes the melting of ice, and expedites the icing of the cars.

The lighting of a yard for night operation.

Yard work is dangerous, difficult and slow, during the hours of darkness and during fog. Electric lights are frequently used for yard illumination, and the switchmen supplement these by leaving a lantern on the ground opposite the end of the last car on each track. The electric lights, as ordinarily used, are not effective, and the cars are handled slowly as a result. The defect of these lights is due to their dimness, the lack of sufficient number, and their ineffective placing.

To overcome this trouble on the humps and ladders, Mr. M. E. Shire, engineer in charge, of the " Clearing Yards," Chicago, has developed a device like the reflector of a locomotive headlight; each light is equipped with one of these, and it is placed so the rays of light are directed toward the important channels of the work. The classification yards are most in need of such a lighting arrangement, and as there are no reverse movements in this yard, not even the slight disadvantage of lines of clear light shining at times in the faces of the switchmen is experienced. While all portions of the yard system should work smoothly and without delay, the work is concentrated at the entrances and on the ladder leads of the classification yard as all cars must enter the yard over a single throat track and go to their respective destinations by way of one of the ladder leads. In addition, the momentum required to start the cars and carry them well into the classification yard must be imparted by the grade of the throat track and ladder leads. Consequently, the maximum speed of the car occurs in its movement over the ladders, and if this speed is checked by the brakes by the rider, because he cannot see the car ahead of him clearly enough to judge of its relative position and speed, the capacity of the entire yard is thereby affected. There are no yards as far as observed where this lack of sufficient light does not lessen the operating capacity during the hours of darkness.

For lighting the ladder leads of the classification yard, one or more of these lights with reflectors is placed at proper intervals from the hump to the ladder end, on poles or on steel bridging similar to the bridging frequently used for signals; the height must be sufficient to avoid casting serious shadows from one car to another, and the reflectors properly trained to throw the rays of light where needed. In the body of the classification yard, these lights are needed in greater quantity, and arranged to sweep the yard at different angles; on the outlet ladders, and in the other yards of the system, this type of reflector is undesirable as the switching is equally backward and forward in direction, and movement toward the lights would be blinded by its rays. Accordingly, the effective arrangement in these places is a general diffused light reflected downward only.

For the Dupo yard of the Gould System, there has been developed under the writer's direction, a similar system of conserving and reflecting the rays of light to the points where they are needed. Based upon this idea, a similar type of reflector was developed by the General Electric Company, in place of the locomotive head-light type, and the reflecting surface instead of being of silver plate or nickel plate, was of porcelain enamel on thin sheet steel. For the ladder leads and the portions of the classifying yards where the light rays are directed forward in one way only, there was developed the type of reflector shown in figures 5 and 6, and for the parts of the yard where only a generally diffused illumination was needed, the skirt was omitted from this pattern. The lights were carried on systems of general current bearing lines of not greater than 440 volts, so arranged that the breakage of a single line would plunge only one part of a yard in darkness. This scheme makes its first cost, maintenance and repair economical and minimizes both the danger to employees, and the amount of interruption to work due to breakage of wire lines. The details of the lighting arrangement constitute in themselves material sufficient for a separate report, and need not be further elaborated here. The writer has not seen any adequate lighting arrangement in use in any yard so far examined, and regards this detail as one of distinct importance.

Don'ts.

A discreet engineer tries to perfect his methods of design and construction, by noting other men's work, profiting by the lessons to be learned both from successful portions, and from the unsuccessful portions. For this reason, it may be well to insert cautionary words here to show what points in yards now operated, have proven clearly undesirable, as an emphasis for the suggestions as to good practice so far given.

Do not attempt to design any yard until thorough study has been made of the business to be handled by that yard; then make the best guess possible at the amount and character of business that can be anticipated for the future. Work out a plan for handling this

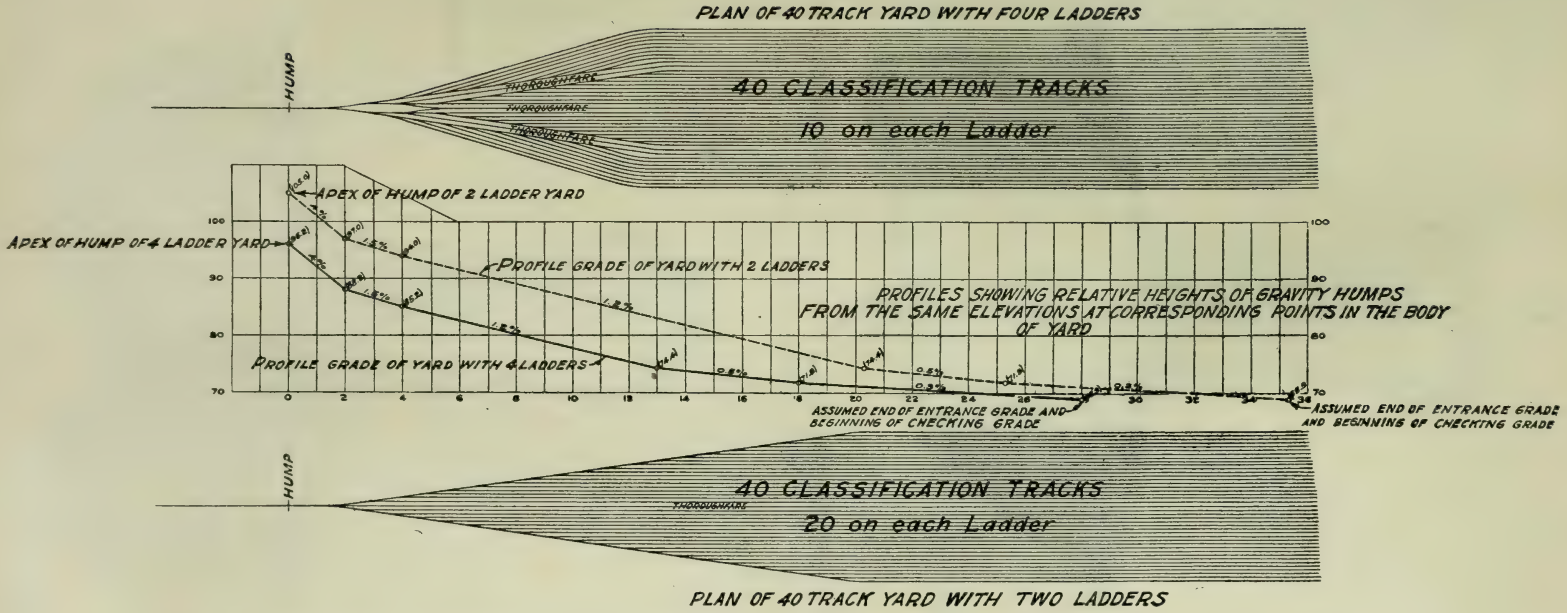

PLAN OF 40 TRACK YARD WITH FOUR LADDERS
HUMP
THOROUGHFARE
THOROUGHFARE
THOROUGHFARE
40 CLASSIFICATION TRACKS
10 on each Ladder
APEX OF HUMP OF 2 LADDER YARD
APEX OF HUMP OF 4 LADDER YARD
PROFILE GRADE OF YARD WITH 2 LADDERS
PROFILE GRADE OF YARD WITH 4 LADDERS
PROFILES SHOWING RELATIVE HEIGHTS OF GRAVITY HUMPS FROM THE SAME ELEVATIONS AT CORRESPONDING POINTS IN THE BODY OF YARD
100
90
80
70
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
ASSUMED END OF ENTRANCE GRADE AND BEGINNING OF CHECKING GRADE
ASSUMED END OF ENTRANCE GRADE AND BEGINNING OF CHECKING GRADE
HUMP
THOROUGHFARE
40 CLASSIFICATION TRACKS
20 on each Ladder
PLAN OF 40 TRACK YARD WITH TWO LADDERS

Fig. 4. — Comparison in a given yard of 40 body tracks, of the relative heights of gravity humps between the two ladder method and the four ladder method of design.

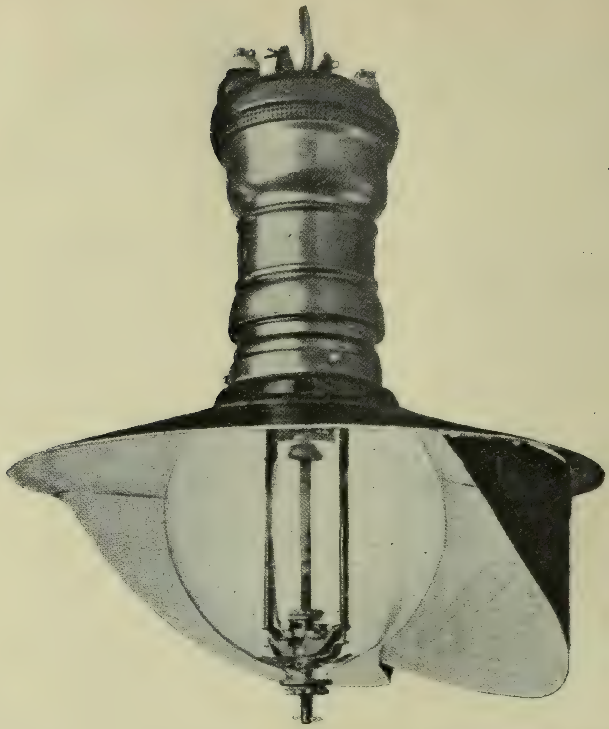


Fig. 5. — Front view of alternating current enclosed arc lamp with reflector for directing rays of light forward and downward.

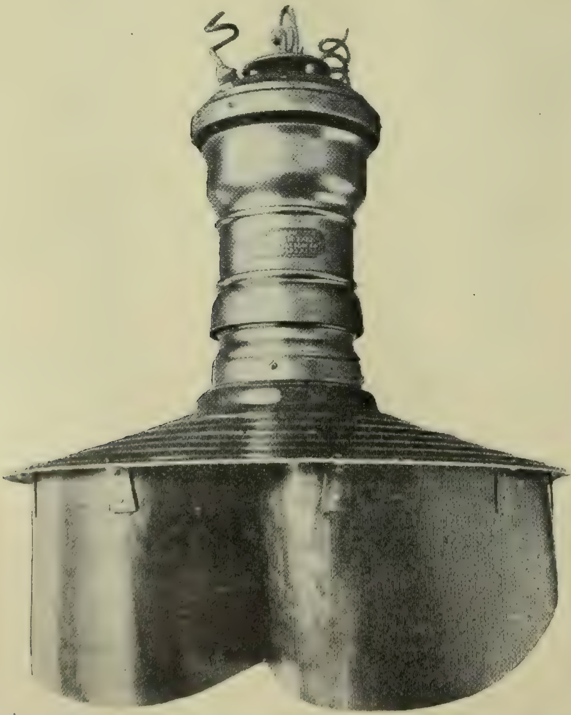


Fig. 6. — Rear view of direct current luminous and alternating current arc lamps with reflectors for directing rays of light forward and downward.

future business; for the present arrangement, plan to build the proper proportion of the final plan, so far as possible on the lines of the final scheme. Do not limit the land purchases so as to interfere with a good working arrangement. Do not attempt to adopt types and methods of design for comparatively small amounts of business, that are succesful only with heavy business. For instance, there is no justification for building a hump yard to handle the general merchandise, lumber, grain and coal traffic of the ordinary division station, or ordinary terminal station. The hump yards that have been built at a number of points for comparatively small business, are so far as observed, costly and unsatisfactorily in operation and the best operating men agree that the hump yard type is as inadvisable for moderate business as it is essential for heavy business.

Do not neglect the proper lighting of a yard for night work, until the yard is under construction or later. The best location for the necessary light carrying poles should be provided by spreading the tracks to admit them without peril to trainmen at work. Note carefully the methods of conserving and directing the rays of light outlined earlier in this article, and adapt them to each portion of the proposed yard to suit the respective switching movement.

Do not permit curvature in excess of eight degrees per station in any important parts of the yard; do not introduce any avoidable curvature even within this limit; do not fail to compensate for curvature in hump and gravity yards, in the portion where gravity is used as motive power.

Do not fail to arrange for surface drainage.

Do not fail to provide sufficient spacing of tracks for convenience in giving and seeing signals, and throwing switches, and the other work of the yard.

Do not fail to provide sufficient drilling tracks so that switch engines can work freely without friction or interference with each other, or with incoming or outgoing trains.

Do not, even in the smallest yard, attemp to have the car repairs made, or cabooses or wrecking outfit stored, on tracks in the body of the yard, — put them on tracks of their own outside.

Do not lightly decide where the scale shall be placed. Give this item the most careful thought.

Do not make the classification tracks too long, as delay and extra expense in switching is thereby occasioned.

Do not couple too many body tracks to a single ladder.

Do not forget that a yard should be as elastic as possible for present use, and so design that future enlargement will be on a harmonious scheme.

In conclusion.

There is submitted as figure 1, outline drawing of the terminal yard designed by the writer, for the East St. Louis territory of the Missouri Pacific Railway, the St. Louis, Iron Mountain & Southern Railway, the Cotton Belt Railway, and for the incidental use of the Wabash Railroad. This yard is now under construction, practically all the grading being complete, and a considerable portion of the track laid. Portions of the yard have been in use since about October 1st, 1905. About one-half the trackage called for on this plan is to be built as the first installment of the terminal, the balance being provision for the future.

This plan is submitted as the writer's idea of the application of the principles of yard design, for the conditions prevailing in the East St. Louis territory.

It is a matter of regret that the plan submitted for the Buffalo terminals of the New York Central lines cannot be shown.

This plan has been approved by the operating officers of each company, but as it is still under consideration by the executive officers, it is improper to publish it just now.

It seems unwise to develop a so-called typical yard plan for insertion herein, because no two yards are alike. The lay of the ground, the character and amount of the traffic, the relative position of connecting lines, the ruling grades of the avenues for forward movement, all affect the design that can properly be used, and a design worked out in the best good faith for one situation, or for an assumed situation might be not only uninstructive but misleading if applied to other points.

The general matter of railway terminals is one of importance. The expense of handling traffic through illy arranged yards is not only heavy in the direct cost for labor and for damages to contents of cars in reswitching, but indirectly in the lessened income from the cars themselves, and from the loss of traffic that results from delay and embargo. The writer has knowledge of one case where under as favorable operating methods as the situation permitted and during a time when business was moderate a forward movement of about two and one-half miles was made in 46 hours on an average during the period investigated, and many cars were lost track of in the confusion of movements that was unavoidable. This is not believed to be an extreme case. The cost of a trackage scheme in this particular instance that would have been adapted to the work of switching would not have been excessive and the net saving would have been very great. It not infrequently occurs that the major portion of a yard is well arranged, but the switching is interfered with by improperly placed switches or a bad ladder scheme or drilling tracks that are difficult to use; under such conditions a small investment in rearrangement may make the yard serviceable and economical in use.

In the improvement of such existing yards, or the design of new yards, there is one suggestion the writer respectfully makes to those who may undertake such work; that is, study thoroughly the work that must be done to arrange traffic for forward movement, and then arrange tracks so this work can be done in the simplest, easiest way by direct movements, free from friction. Any track scheme that will not stand thorough analysis on this basis may well be regarded as suspicious; any scheme that invites derailment, or that necessitates large forces of men when business is small, or that makes reswitching continually necessary, or that calls for elaborate construction where simple construction is sufficient, or that fails to provide for the auxiliary work, of a yard, should be avoided.

To learn from the good features and the less desirable features of existing yards, those lessons needed in the design of a new terminal, requires thorough investigation on the ground; not an investigation of a few hours or a day during favorable weather, but days and nights of watching the work, during good weather and bad. Time is often hard to spare, but there are few lines of work where thoroughness is more essential than in terminal design.

[656 .253]

THE DRIVER'S CAB SIGNAL.

Figs. 1 to 6, pp. 621 to 630.

The following information concerning this new repeating signal is the summary of a pamphlet edited by the Western Railway Syndicate, Limited, 31, Budge Row, London, E. C., and from an article of the *Railway Gazette*. We leave the entire responsibility for the information contained in this article to these sources.

For some time past, the Great Western Company has been making experiments with a new audible signalling arrangement. This system is now undergoing practical test on the branch line to Fairford, in Gloucestershire, 22 miles long. The arrangement may be regarded as representing the efforts made by the Great Western Company to find a new and reliable method of safely and expeditiously signalling trains during foggy weather, or when from other conditions the semaphore signals are not readily visible. It is claimed that the new system has the advantage of being in constant use, and so guarding against possible forgetfulness on the part of an engine driver, even in clear weather, as will be apparent from the following detailed description.

The apparatus is fixed in the engine cab, and indicates to the engine driver at or near the spot where the distant signal is usually placed, the exact position of the stop signals in advance with which the distant signal would be interlocked.

The signals given in the engine cab are audible and visual.

The audible signals are as follows :

Danger : a special steam whistle;
All right : an electric bell.

The "caution" signal is operated by the destruction of a local electric circuit on the engine, effected by the lifting of a lever or plunger, which invariably occurs at each signalling position.

The "clear" signal is actuated by an electric current, picked up from the ground apparatus by the lever or plunger, the current in addition to causing the bell to ring, preventing the operation of the "caution" signal.

Since the operation of the "caution" signal depends upon the lifting of lever or shoe, while the suppression of this signal depends upon the successful picking up of an electric current, it will be seen that neither frost, snow, nor electrical failure can have the effect of preventing the operation of this signal.

Once sounded, these signals continue to sound until stopped by the engine driver and are applicable on double and single lines of railway.

Both the danger and the all right signals are given by the signalman to the engine driver without moving any apparatus on the track, the ground apparatus being a *fixed* ramp.

The visual indications are :

Danger : red ground with word " Danger ";
All right : white.

These indications in all cases correspond with the audible signals received.

Reference to figure 1 will show how the " caution " signal is operated and restrained. At each signalling position, there is fixed in the centre of the running rails a ramp R consisting of a bar of T iron, suitably mounted and insulated on a timber base, the highest point of which is 4 inches above rail level. The iron bar is electrically connected by means of a telegraph wire to a switch S¹ at the signal-box. By means of the switch, a battery B¹ is put in connection with the ramp when it is desired to give the " clear " signal on the engine, otherwise the switch S¹ is not closed and the battery B¹ disconnected. The contacting shoe L on the engine is insulated from the mass of the engine, and the switch S, which is mechanically connected to the shoe, is insulated both from it and the mass of the engine. The normal position of the shoe is such that its lowest point is 2 $^1/_2$ inches above the rail level, and it is fixed to the engine in such a position that it comes in contact with the ramp R, in passing over which it is raised 1 $^1/_2$ inch. The electro-magnets E and E¹ on the engine, have armatures yoked together and the compound armature K thus formed is capable when held, owing to either of the electro-magnets being energised, of keeping closed the valve V of the whistle W. The whistle valve is constructed on the principle of the safety valve, and is normally prevented from opening by the armature being held by the electro-magnet E. This electro-magnet forms part of a local circuit on the engine, which includes the battery B and the switch S. As already mentioned, the switch is mechanically connected to the shoe L, and when the latter is in its normal position, the switch is closed; the local circuit then being complete, the electro-magnet is energised and is capable of holding the compound armature, and, through it, of keeping the whistle valve closed. The lifting of the shoe L less than $^1/_2$ inch above its normal position will open the switch S, and, in these circumstances, the electro-magnet E will no longer be energised, and consequently be incapable of holding the compound armature. Thus, when the shoe passes over the ramp, and is raised 1 $^1/_2$ inch, the local engine circuit is opened and the whistle sounded. On the shoe clearing the ramp and the local circuit being again completed, the electro-magnet is once more capable of holding the compound armature, but in order that it may do so, the driver must lift the armature near to the poles of the electro-magnet, for which purpose a small lever, L¹, is provided.

The foregoing explains the method of operating the " caution " signal. When it is desired, on account of the line being clear, to suppress that signal, the signalman connects the battery B¹, by means of the switch S¹ (operated by a lever in the locking frame, which is preceded by the home and starting signals), to the ramp R. The electro-magnet E¹ is electrically connected on one side to the shoe L, and on the other side, to earth through the mass of the engine and the running rails. The shoe, in passing over the ramp will, under these circumstances, in addition to opening the switch S, also complete an electric circuit comprising the battery B¹ and the electro-magnet E¹. Consequently, the latter will

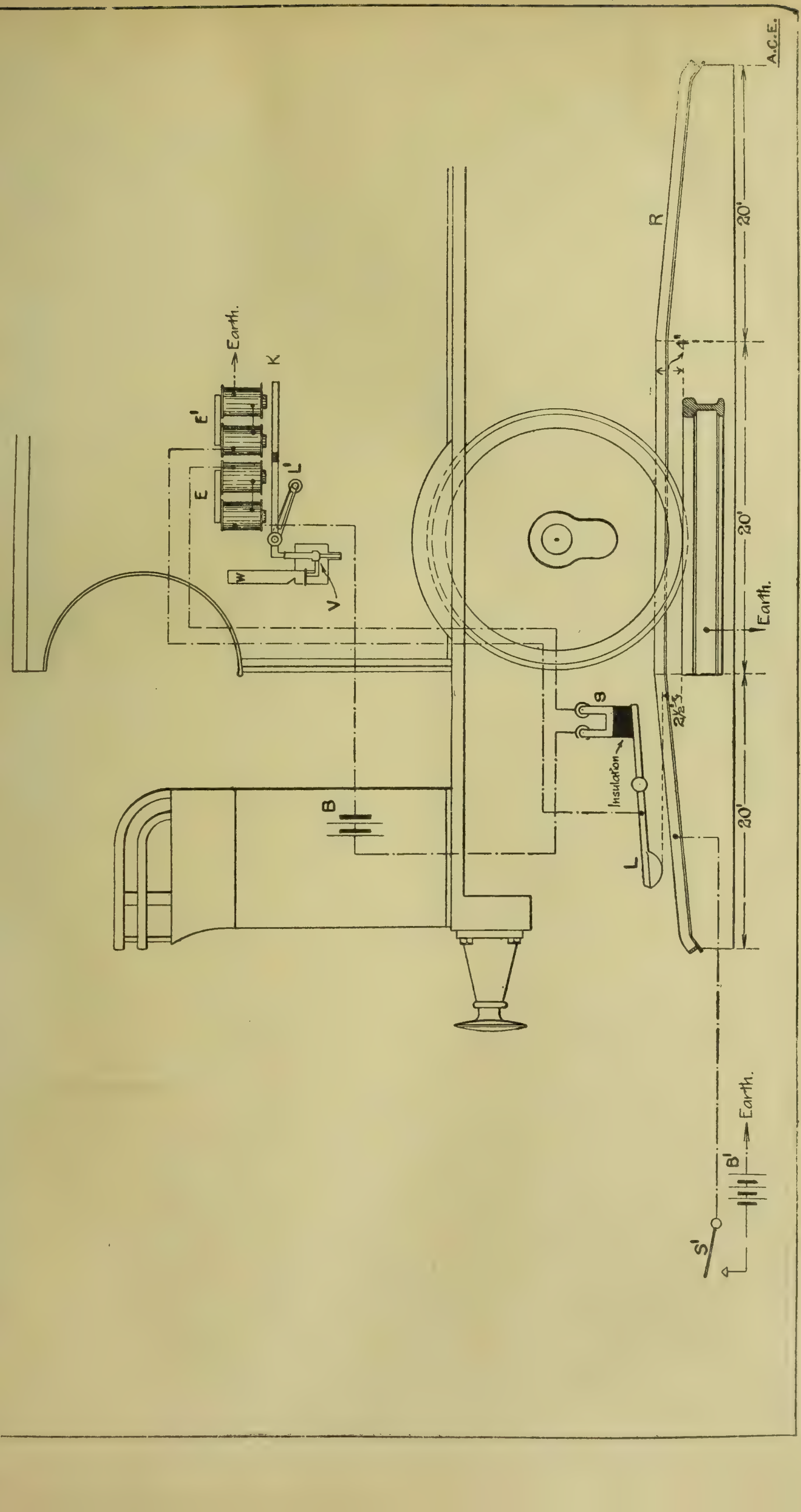
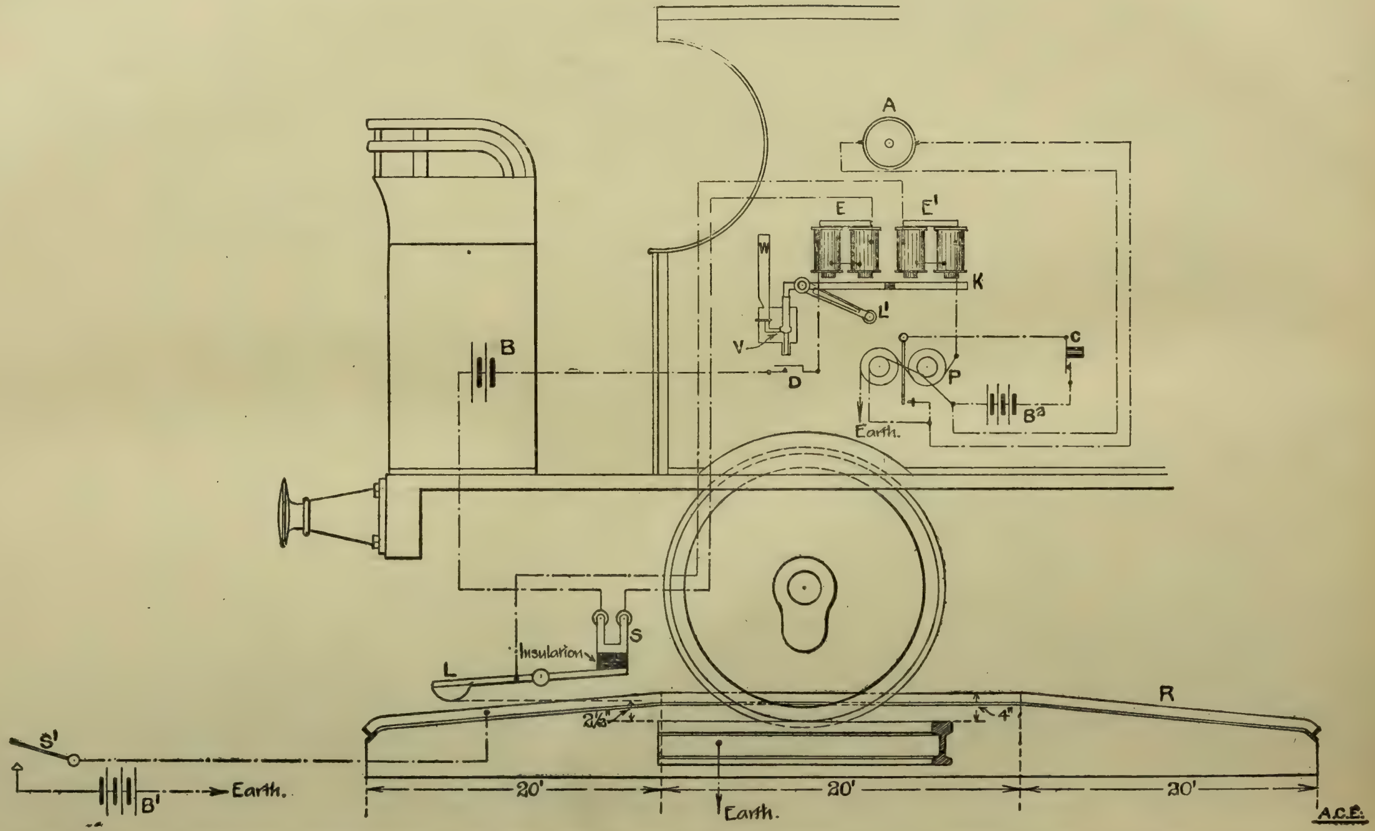


FIG I.

FIG 2.


A
E
E'
K
W
L'
V
C
B
D
P
B^2
Earth.
Insulation
S
L
R
$2\frac{1}{2}''$
4"
S'
B'
Earth.
20'
20'
20'
Earth.
A.C.E.

be energised and be capable, during the passage of the shoe over the ramp, of holding the armature and keeping the whistle valve closed. The suppression of the " caution " signal is not in itself a positive " clear " signal, this consisting, as already mentioned, of the ringing of a bell. Figure 2 is an amplification of figure 1, showing on the engine in the circuit of the electro-magnet E^1 one winding of a polarised relay P. When current is picked up from the ramp, it will, in addition to energising the electro-magnet E^1, also energise the polarised relay, the armature of which will close a local circuit comprising the Battery B^2 and the bell A. The second winding of the polarised relay is for the purpose of keeping the local bell circuit closed, so that the bell may continue to ring after the shoe has passed over the ramp and until the bell circuit is momentarily opened by the driver operating the breakpush C. Figure 2 also shows an additional device in the local circuit of the electro-magnet E. This is a switch D, which is controlled by a steam-operated valve, so arranged as to open the circuit when the boiler pressure falls to about 20 lb. This ensures the automatic disconnection of the battery B, and prevents waste of current when the engine is not in running condition.

The line battery B^1 consists of about 16 No. 2 Leclanché cells; battery B of two large dry cells, and battery B^2 of four small dry cells. The relative positions of the shoe and ramp are shown by figure 3.

For fast-running lines, a ramp 60 feet long has been found suitable; for branch lines, 40 feet. The ramp must be long enough to ensure the switch S being open a sufficient time to effect proper de-energisation of the electro-magnet E (fig. 1) when the shoe passes over it. In connection with the Witney & Fairford line installation, two short ramps are provided in the locomotive yards at Oxford and Fairford, so that the " caution " and " clear " signals may be tested before an engine passes out for use. The highest point of the " caution " testing ramp, is only 3 inches above rail level, therefore the " caution " signal sounds when the shoe is lifted $^1/_2$ inch, or one-third of its working lift.

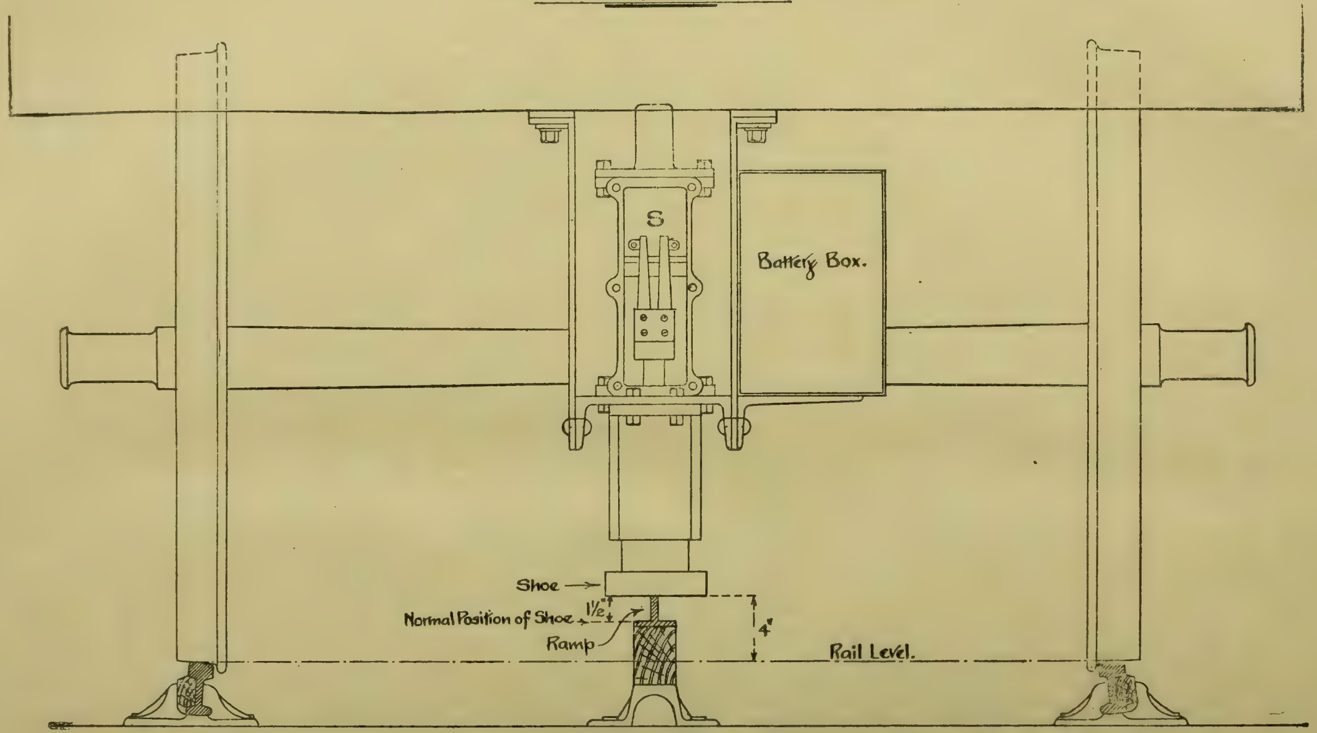
The contacting device or shoe is shewn in figure 4, and has proved satisfactory at all speeds. This shoe has the advantage of being adaptable to any type of engine. The contact portion of the shoe is 7 inches wide, and its face is case hardened. A strong spiral spring is provided for ensuring the prompt return of the shoe to its normal position immediately it leaves the ramp.

The cab apparatus is illustrated in figure 5. The handle at the right hand side is for the purpose of enabling the driver to lift the armature of the electro-magnet to stop the whistle. Particular care is taken in the construction of this apparatus, only the best workmanship and materials being used.

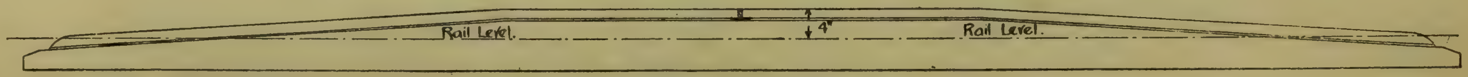
The push button shown below it is to enable the driver to stop the bell.

Although apparatus of this character does not usually provide for working over single lines, it was felt by the inventors that to ignore this form of working would be a serious blot on the scheme. It could hardly be considered satisfactory to use the Driver's Cab Signal as a substitute for the semaphore distant along a main double line track, and suddenly revert to the semaphore system when passing on to a single line. The Driver's Cab Signal has, therefore, been designed to work equally on double and single lines without any alteration when passing from one to the other, in fact, the first instalment approved by the Board of Trade Inspecting Officers was a single line branch 22 miles long, where the semaphore distants have been taken away.

FIG 3.



CROSS SECTION OF RAMP, SHEWING SHOE IN CONTACT.



ELEVATION OF RAMP.

A.C.E.

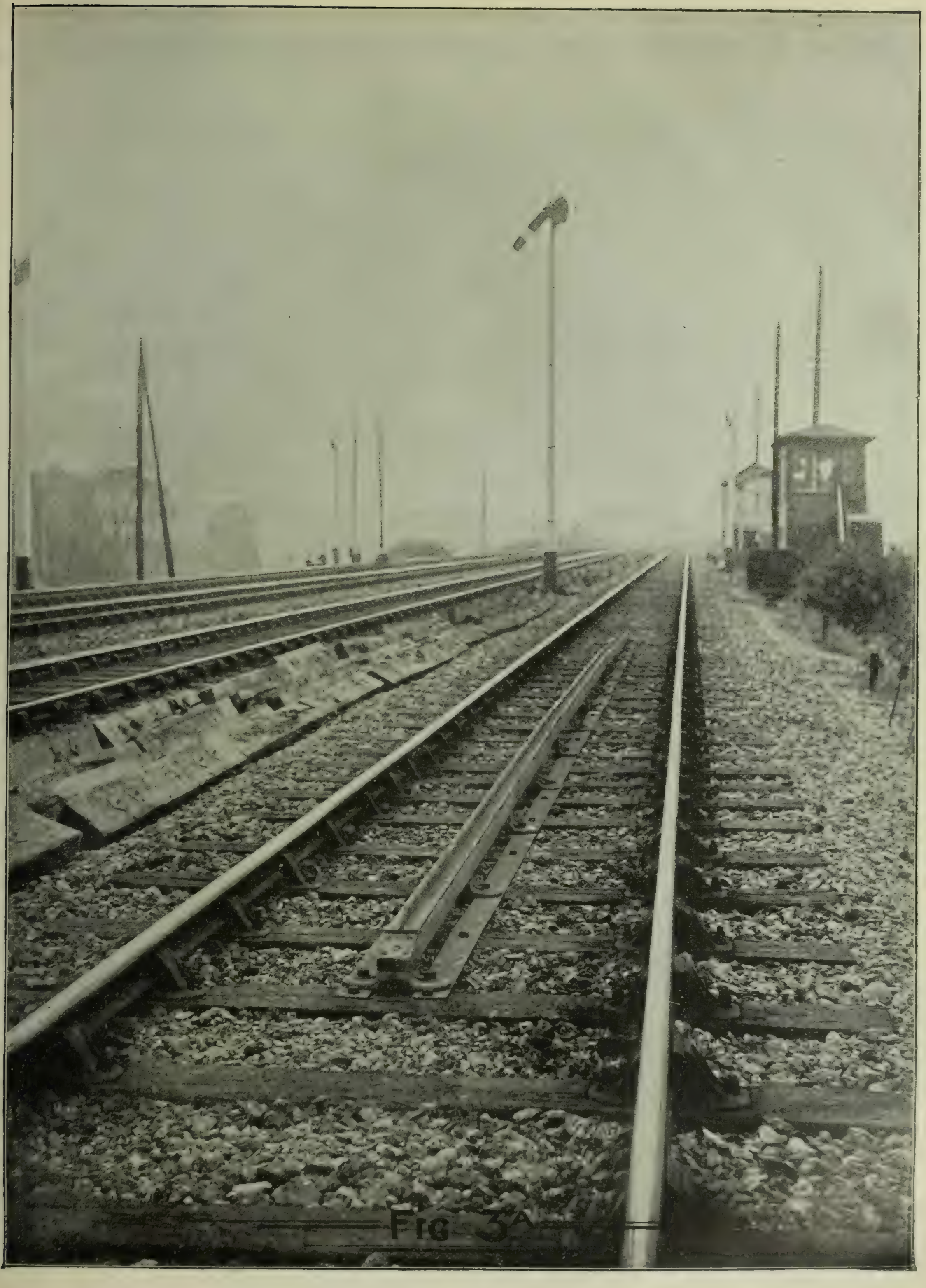


Fig. 3 A.

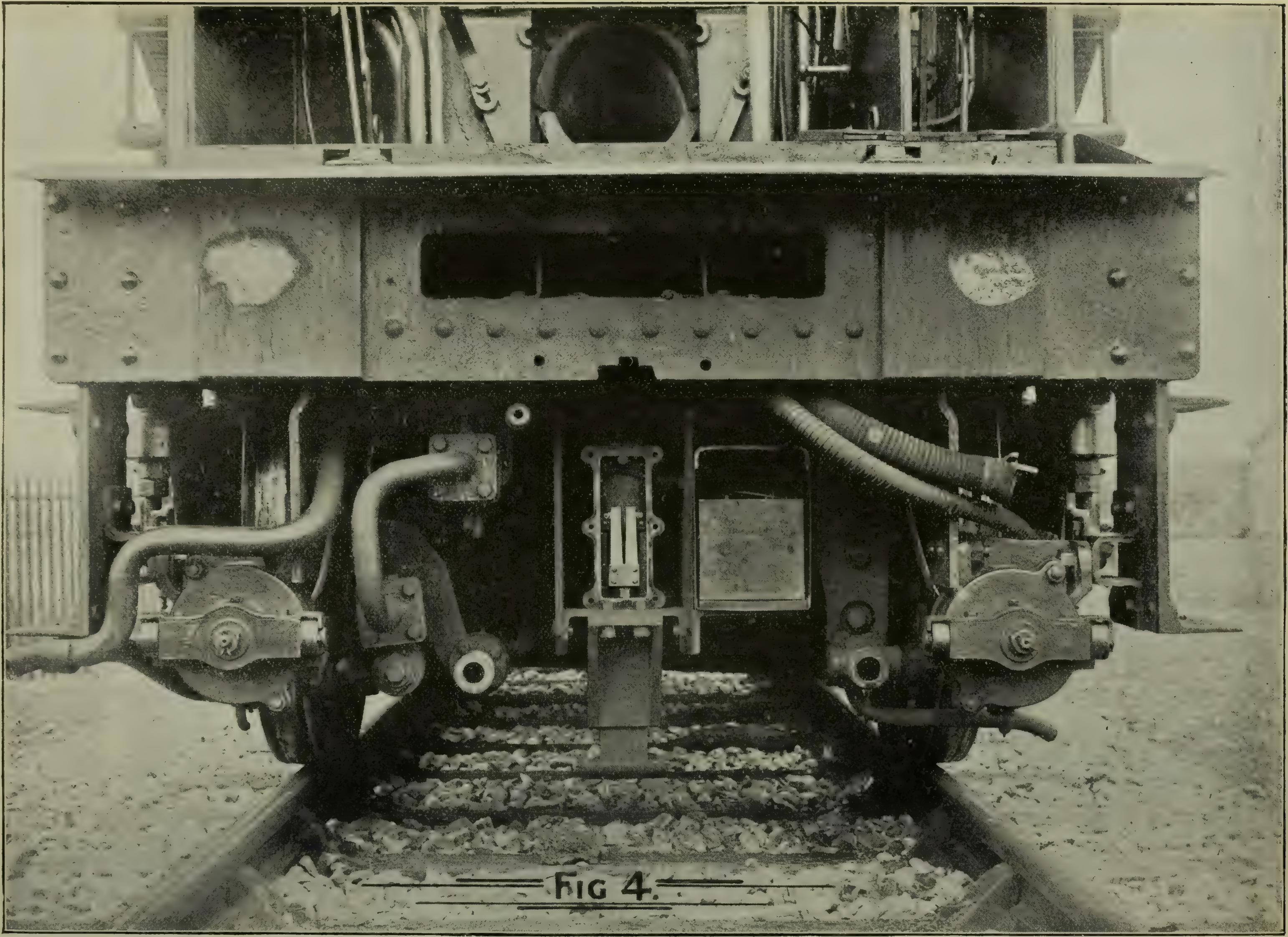
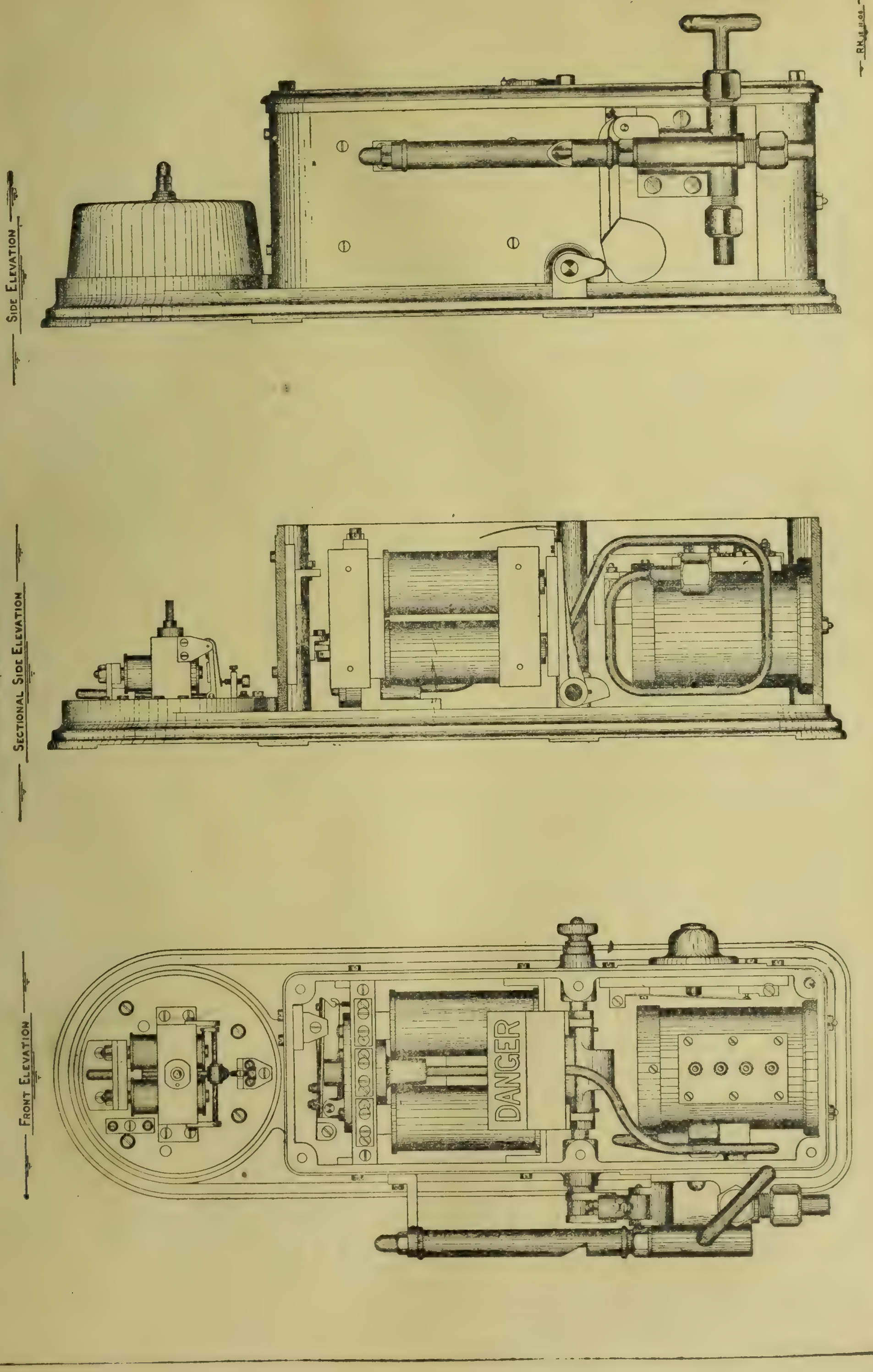


FIG 4.

Fig 5.

Automatic Electric Signal For Locomotives.



In the case of single lines, an engine in passing from one station to another, say from A to B, will pass over two ramps, one applying to trains coming from B, the other to trains going to B, and it is desirable that it should only receive a signal at the latter. Referring to figure 2, it will be seen that the ramp is electrified by the signalman connecting the negative end of the battery B1 to the ramp, and it will be understood that, if instead the positive end of the battery were to be connected to the ramp, the " caution " signal would still be suppressed, but the bell would not ring, since the armature of the polarised relay would tend to move away instead of towards its contact post. It is arranged that this shall happen on single lines when an engine passes over a ramp applying to the opposite direction to that in which it is running, such ramp being positively electrified by the signalman to whose station it applies. In order that it shall not be possible for the signalman to wrongly electrify a ramp when the train is approaching his station, the levers in the locking frame controlling the switches electrifying the ramp are interlocked with the electric train staff or tablet circuit. The lever positively electrifying the ramp is electrically locked and the lock can only be released and the lever pulled over, when permission is received from the other end of the section to withdraw a staff. When a staff is withdrawn the lever is back-locked, keeping the ramp positively electrified until the staff has been restored at one end or the other. These somwhat elaborate arrangements only concern single line equipment. The engine equipment is the same for both double and single line working, and the apparatus on the engine is always in a position to correctly receive signals on whatever line it may be running.

1° A perfect substitute for semaphore distant signals;

2° It presents the following advantages over the present semaphore distant signals :

a) No wrong indication through expansion and contraction of wires, or wires becoming caught up;

b) No distant signal lamps to provide and maintain, thus making possible economies in lamping staff;

c) Electric repeaters for distant signals not necessary in the signal box;

d) Renders simple a perfect system of black slotting for crowded and short sections;

e) Where several running roads run parallel with each other, gives driver signal for the particular road he is on, instead of compelling him to pick out his signal from a number of others;

f) Gives the signal to the driver and the fireman, thus bringing about a perfect check;

g) Each signal must be acknowledged and therefore understood;

h) By giving a *distinct* signal for the distant signal, removes the possibility of the distant indication being mistaken for the home and *vice versa*;

i) The removal of the semaphore distant renders all remaining semaphore signals of the same signalling value;

j) Can be used in tunnels where a semaphore cannot be placed;

k) Is equally efficient in fogs and snowstorms, thus obviating the necessity for the use of fogmen and detonators at distant signals. This is of immense economic value;

l) Is always in operation, thus bridging over those frequent occasions when the atmosphere is thick, but fogmen have either not been called or have not arrived at their posts;

m) "Extended" or "fog block", with its attendant delays rendered unnecessary;

n) Cheaper to instal and to maintain than the present semaphore distant system.

This invention is the outcome of an attempt on the part of railway officers to produce a signal of a reliable character which would inform the driver of a locomotive the position of the stop signals ahead of him, when atmospheric conditions render it difficult, and sometimes impossible, for him to see a semaphore arm.

Since the inception of the idea, however, the scope of the invention has widened, and now the inventors find it not only possible, but desirable to make the Driver's Cab Signal a substitue for the distant semaphore arm, instead of merely an auxiliary as at first intended.

Fogs are frequently patchy in their character, and mislead the signalman into the belief that fogmen are not necessary when drivers really require them.

Fogmen are not always on hand when required, and between the advent of the fog or snowstorm and the arrival of the fogmen, the trains were subject to very considerable risk.

Even when the fogmen had been duly placed, they could not always be relied upon to put the detonators on the rails, neither could the detonators be absolutely relied upon to explode.

The Board of Trade inspecting officers have again and again pointed out the need for a more reliable mechanical apparatus for warning drivers of the position of their signals, and their views appear to have been considerably strengthened in this direction by the accidents at Cudworth, Ulleskelf, and Slough, in reporting on which the following remarks appear :

Cudworth. — "The inspecting officer found that this collision was caused in the first instance by the entry of the up express into a block section already occupied by the mail train, and this was brought about by the express train running past danger signals at a high speed in a thick fog.

"Two points have to be established before the adoption of any system of purely automatic or mechanical fog signalling can be advocated in preference to the manual system now chiefly in use on English railways :

"1° It must provide both a positive as well as a negative indication. It must duplicate the safety as well as the danger position of signals;

"2° It must be absolutely reliable under all conditions.

"This case proves the necessity to supplement and improve the existing manual system."

Ulleskelf. — "This accident, like several previous one, points to the durability of the provision of some reliable mechanical contrivance to notify to a driver that he is running past a signal.

"The introduction of a reliable apparatus for the purpose is urgently needed, and the matter is therefore one which calls for the attention of the railway companies."

Slough. — "In consequence of this collision, considerable prominence has been given in the public press to the suggestion that some mechanical contrivance working in conjunction with the semaphore signals be adopted te render it impossible for a driver to pass a danger signal without becoming aware of the fact."

It is not too much to say that while the apparatus would undoubtedly solve the problem of fog signalling, with its expense, delay, and danger, it would be beneficial to drivers only in a slightly less, degree when the weather cannot be said to be foggy.

Such accidents as the Slough and Grantham disasters (1) would hardly occurred if an audible reminder had been given to the enginemen. No mistakes through absent-mindedness are possible, because the enginemen get an audible and visual signal on the engine as against " sight only " in the case of the semaphore distant signal. The audible signals give the driver and fireman a perfect check on each other, which cannot be said of the present semaphore distant signal.

On account of curves, etc., the practice has hitherto been for the man who could best sight the signal to do so, and in the case of the fireman, advise his mate as to its position. The Driver's Cab Signal advises both men at the same time. Frequent misunderstandings have arisen with the old system, a driver sometimes thinking his mate had sighted a signal at " all right " when such was not the case, and many cases have happened in which the semaphore distant signal has been missed altogether, as the result of which serious mishaps have occurred.

In short sections the apparatus is particularly valuable. With the present semaphore distants, it is not practicable to put the distants back sufficiently far to give the driver his proper warning, and some expedient in the shape of an instruction to the signalman is all that can be devised. With the Driver's Cab Signal, however, a perfect system of slotting is rendered possible.

The following diagram will illustrate the advantages to be gained in this way :

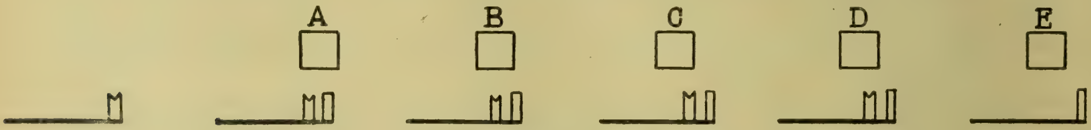


Fig. 6.

The line from A to E consists of short block sections not in any case more than 500 yards in length, and each signalman simply controls his own distant, which in the case of B, C, D and E, is a lower arm on the stop signal of the box in the rear. If, therefore, C wishes to stop a train, the only signals at his command are his distant on B's home, a distance of say 400 yards to the rear, and his own home signal. This cannot be regarded as sufficient in these days of fast running and heavy trains. If to avoid the risk of over-running, instructions are issued to B to keep his distant at danger also, there is risk of delay, because it is obvious the same instruction would apply through the whole series of short sections, and in the attempt to give a driver sufficient warning, the companies are compelled to give him a great deal too much, thus resulting in serious delays. With the Driver's Cab Signal, however, the distant signals, in the case of short sections, are slotted in pairs, thus enabling each signalman to work his signals in the normal manner, and at the same time, giving the drivers a sufficient and proper warning well back from the stop signal at which they are required to come to a stand.

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(1) Vide *Bulletin of the Railway Congress*, No. 1, January, 1907, p. 127 : " The Grantham accident."

[621 .33]

THE LONDON & NORTH WESTERN ELECTRIC RAILWAY.

Figs. 1 to 10, pp. 633 to 636.

(*The Tramway and Railway World.*)

Reference has been made in the Parliamentary notes in previous issues to the proposal of the London & North Western Railway Company to construct an electric railway from their London terminus at Euston Square to Watford, a distance of about 19 miles. This project differs essentially from that of any other railway company in the country which has adopted electric traction. In those cases, existing steam lines were simply changed over from the one system of haulage to the other with a view to increasing the carrying capacity. The object has always been attained, as it has been possible to run much more frequent services, and, as on all such lines the stations are close together, it has been found that the average train speed has been considerably improved, owing to the more rapid acceleration obtainable with electricity. In some cases in London, the change has been accompanied by an increase of working expenses, but experience elsewhere has shown that this is likely to be only a temporary phase, and that the railways which have made the change will ultimately be substantial gainers. It has also to be observed that in nearly all cases of railway conversion in this country from steam to electric power, the change has been made on routes where a large passenger business is done and where there is little or no goods and mineral traffic.

The scheme of the London & North Western Railway Company, particulars of which will now be of interest in view of the approaching consideration of the plans by Committees of Parliament, is quite a different one. The company has an extensive terminus at Euston, which is already fully employed, and their main line running out from it is crowded with long-distance fast trains, slow trains stopping at all stations, goods trains, and mineral trains. There is the usual bottleneck at the northern end of the station to cause delays, and the traffic is always increasing. It is true that for many miles out from London the company have a four-track line, so that the way is comparatively clear for the express traffic; but, even so, congestion is becoming more and more pronounced. A somewhat similar state of things prevails at the London termini of all the great railway companies running out of the metropolis. To the London & North Western directors the alternative presented itself — to electrify their existing railway from London to some

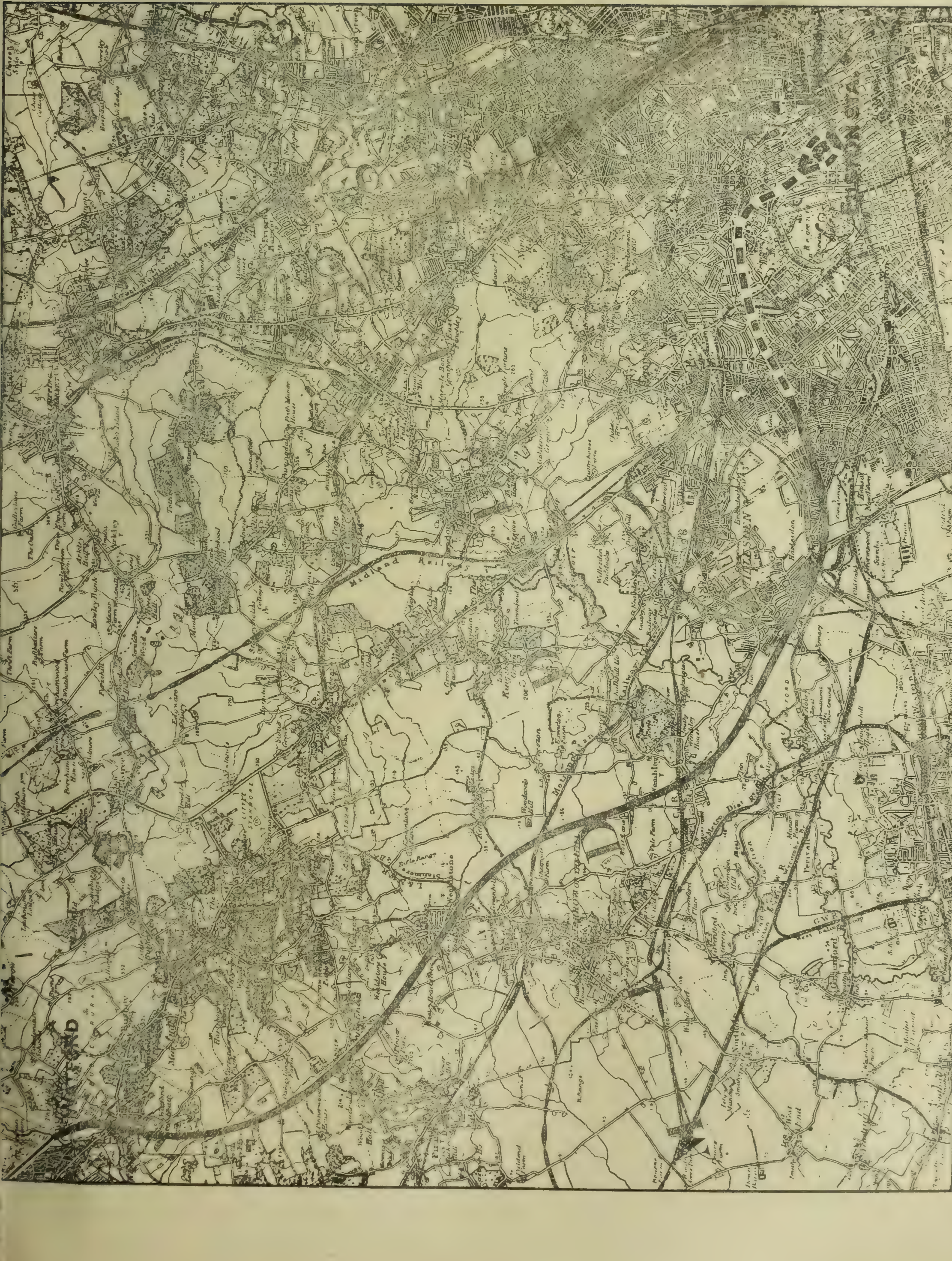


Fig. 1. — Map of proposed electric railway from Euston to Watford.

(The broken line represents the part of the line to be in tunnel.)

point well out in the country, or to go to the expense of building a new line to relieve the pressure on the old.

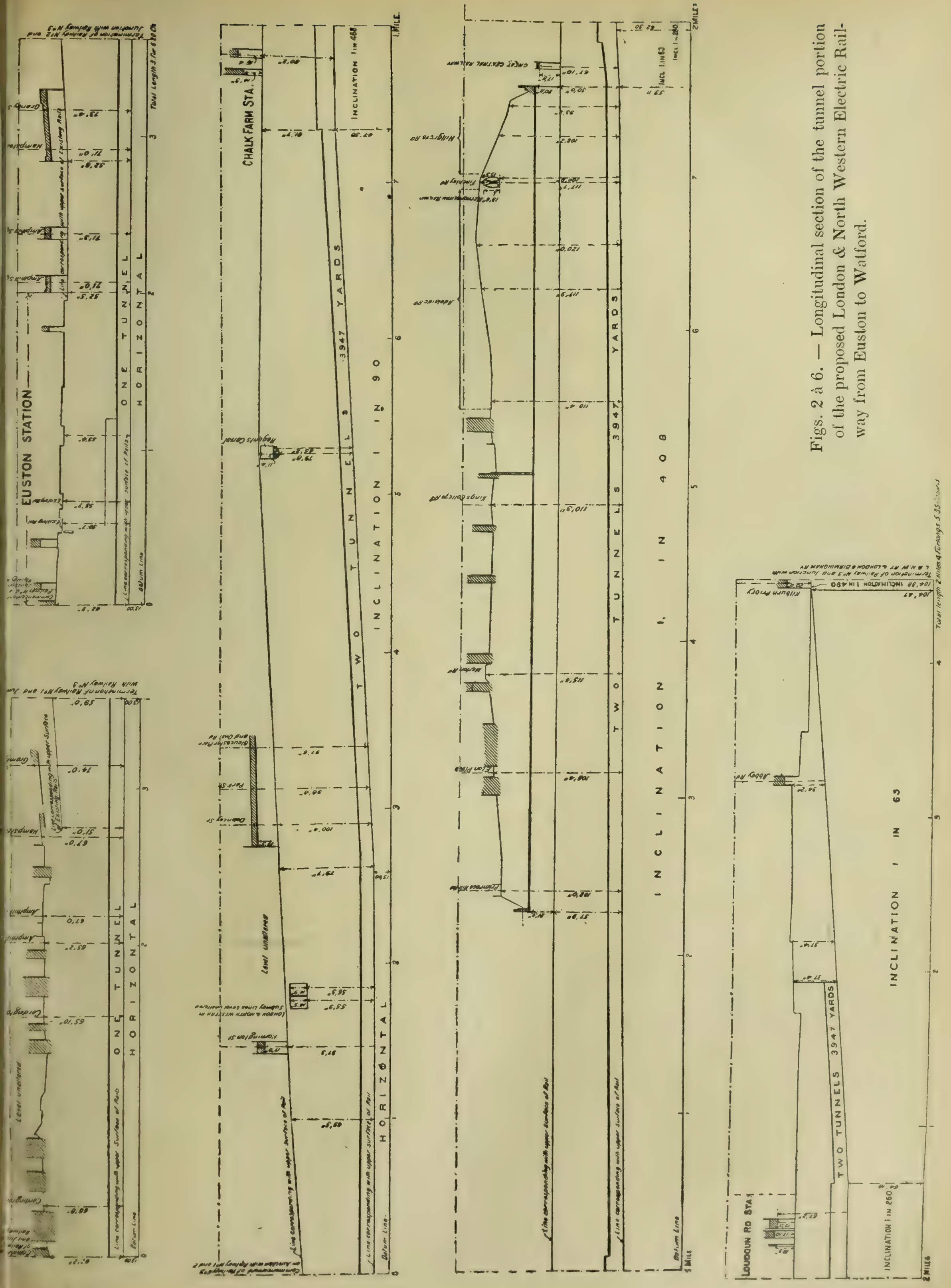
The former plan would undoubtedly largely increase the capacity of the existing railway, so far as local trains are concerned, because the multiple-unit system could be used, thus abolishing separate locomotives and also shunting at the terminus. But for the long-distance trains — whether passenger, goods, or mineral — it is impossible to use the multiple-unit method, seeing steam traction would continue over the greater length of the long journeys, and electric locomotives would be required, entailing shunting and delay as at present.

The other alternative presents many advantages. A large proportion of the passenger trains running out of any London terminus is mainly or wholly local trains for the service of suburbs and outlying districts. If these can be got off the main line, that system of tracks can be cleared for what may be described as serious railroading — namely, the running of long-distance trains of all kinds. This obvious consideration must be before the boards of all the great railways with termini in London, but the North Western board is the first to act on it. The present line — the original London & Birmingham Railway — will not be interfered with; steam trains will run upon it as hitherto. But, partly underneath it and partly alongside, a new railway is to be constructed for a distance of nearly 20 miles into the country, which will be devoted solely to local traffic.

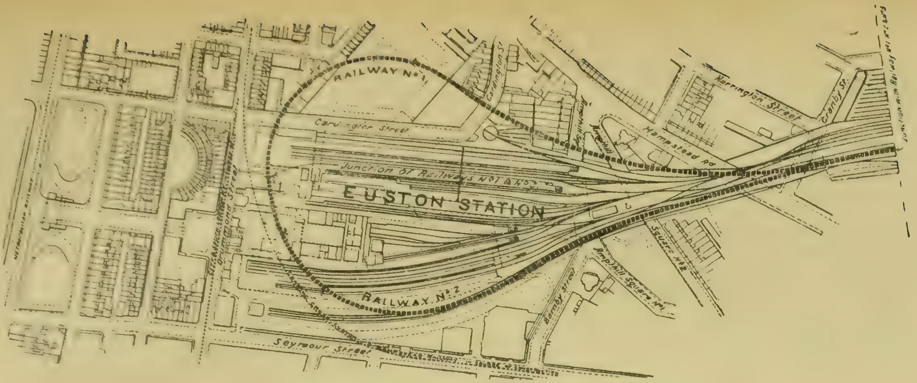
The benefits to be derived are two-fold. Firstly, there is the relief to the main line already alluded to, which will enable the through traffic to be developed as required. Secondly, there is the new railway, devoted solely to local traffic, which is capable of an almost indefinite expansion. The country between London and Watford will in a few years be very largely developed as a residential area, and it is impossible to predict to what magnitude the traffic may eventually grow. It may be recalled that north-west Middlesex and adjoining parts of Hertfordshire and Buckinghamshire are also served by the Metropolitan, Great Central, and Great Western Railways, while the Charing Cross, Euston, and Hampstead Railway, with its continuations to Edgware and Watford, is coming along. There will be considerable competition to certain districts, but the increasing means of communication must produce a great increase of population in what is now open country.

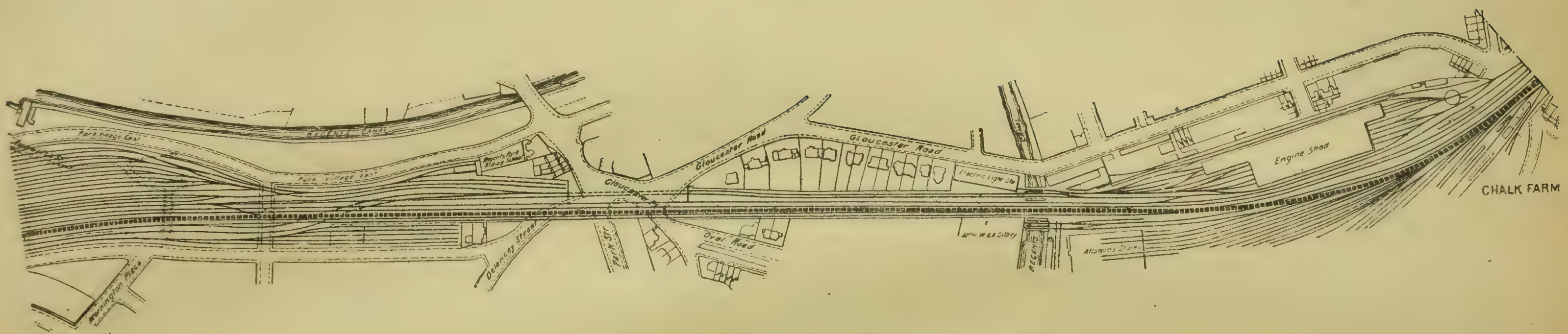
It should be noted that, besides existing traffic, the electric railway will derive considerable traffic from the Charing Cross, Euston, and Hampstead Railway and the Euston extension of the City & South London Railway, both of which are at present nearing completion, and will have stations communicating with the Euston terminus. The proposed line will thus form a part of the great network of electric railways of London.

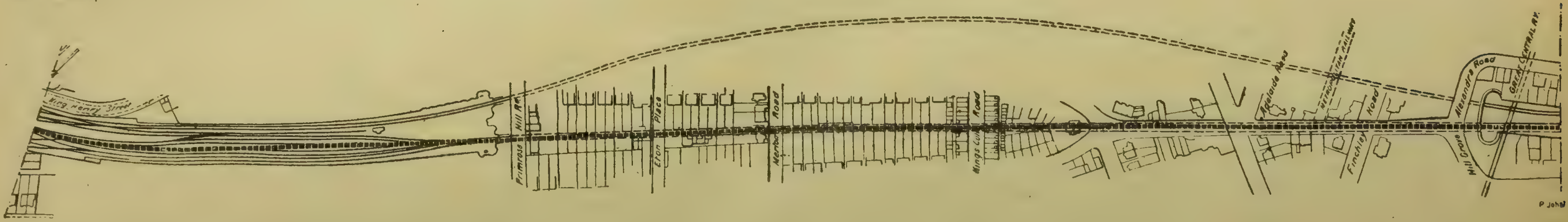
In making the terminus of the new railway under the existing Euston station, the company are adopting a plan similar to that recently carried out in New York by the New York Central & Hudson River Railroad. There is, however, one important difference. The new railway of the London & Western Company will be independent of the main line, which is not to be used at all by the local trains; while, instead of the usual deadend terminus, with a number of docks and platforms, the North Western Company propose a single-track pear-shaped loop. The construction of this loop, without going under many streets or houses, is rendered possible by the great area of ground now occupied by the Euston terminus, and the result will be that not only will there be no shunting, but

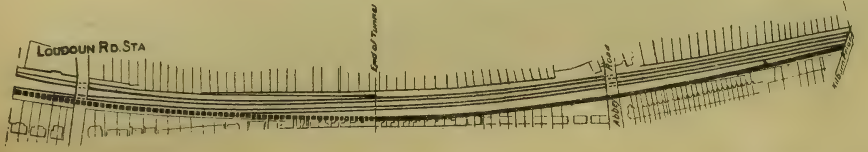


Figs. 2 à 6. — Longitudinal section of the tunnel portion of the proposed London & North Western Electric Railway from Euston to Watford.









Figs. 7 to 10. — The London & North Western Proposed Electric Railway from Euston to Watford. — Plans of the underground terminal loop at Euston and of the part of the proposed line in tunnel.

that the driver of the train will not require to shift from one end of it to the other at Euston before starting on the return journey. The train, on arriving, will simply discharge its passengers, take in a fresh load, and continue round the loop and away to the country again. This plan will also permit of the use of electric locomotives without shunting, should that be desired.

The provisions of the bill which the company are promoting in the present Session of Parliament, as far as they refer to the electric line, ought to be accepted with comparatively little opposition, and there seems every reason to anticipate that the scheme will pass into law. The more interesting and the more expensive part of the undertaking in proportion to length is the London underground portion; and with in regard to this, we present a series of drawings which clearly show the arrangements. The total length of the railway is 18 miles 65 chains of double track and 72 chains of single, the single track being the balloon loop under Euston terminus. The total estimated cost is £2,195,842. This does not include the cost of electrical equipment or of a generating station to be erected near Wembley, but embraces all construction work, tunnelling, permanent way, land, etc.

The underground line at Euston will be about 70 feet below the surface, and will be constructed in a single tube tunnel of 13 ft. 6 in. in diameter and 30 feet at stations. This diameter of running tunnel is about mid-way between that of the Great Northern & City Railway and that of the Central London and the Underground Electric Railways Company's lines. The total circumference of the loop will be 7 furlongs 2 chains. The estimated cost is £202,085, of which the main items are £94,374 for tunnels and £80,600 for the station. A passenger subway from Euston Road to the low-level station is estimated to cost £22,088.

At the northern end of the loop, the two separate tunnels will come close together but remain distinct, and will run as twin tubes as far as Loudoun Road, Hampstead, a length of 2 miles 45 chains, making the total length underground nearly 3 miles. Near Loudoun Road the line, which will be on a gradually ascending gradient, comes to the surface, and then runs alongside the existing railway. From Euston to Chalk Farm the gradient is 1 in 90, and from Chalk Farm to Loudoun Road 1 in 468. The estimated cost of this section is £760,359, among the items being £365,800 for tunnels, £48,000 for retaining walls, £24,308 for permanent way, £179,500 for stations (at Chalk Farm and Loudoun Road), and £61,982 for land and buildings.

After coming to the surface, the railway will run along the old line on the south-western side for a distance of 1 mile 23 chains to near Willesden, the estimated cost of this widening, as it is officially described, being £189,250, of which £13,800 is for bridges, £20,200 for retaining walls, £18,450 for stations, and £110,961 for land and buildings.

Just before reaching Willesden, the railway crosses over the north-eastern side of the main line, and sweeps round to avoid the extensive sidings of Willesden Junction. It again crosses the existing railway south of Wembley station, and this section ends at Wembley, it length being 1 mile 37 chains, and its estimated cost £509,653. The main items are £55,352 for earthworks, £14,170 for bridges, £107,560 for accommodation, bridges and works, £31,000 for tunnels, £49,000 for retaining walls, £25,919 for permanent way, £41,760 for stations, and £144,076 for land and buildings.

The next section, described as widening No. 2, extends to Watford, a distance of 9 miles

28 chains. The new tracks will be on the south-west side of the main line. The estimated cost is £420,293, of which £52,350 is for earthworks, £45,000 for bridges, £13,000 for viaducts, £34,300 for retaining walls, £54,241 for permanent way, £86,300 for stations, and £77,433 for land and buildings.

In Watford itself, there are two new junction sections — one 61 chains in length, joining the main line with the Rickmansworth branch, and the other 30 chains long, uniting the new railway with the Rickmansworth branch. The estimated costs of these respectively are £77,815 and £12,389. A single-track widening of the Rickmansworth branch railway is also to be carried out, and a branch constructed to Croxley Green.

The cost of the electric generating station will largely depend on whether the company intends to provide buildings for possible extensive future requirements, and on whether plant will be put in, as it might economically be, for lighting all stations of the company whithin a wide radius, working cranes and other railway plant, etc. In any case, the land on which it is proposed to erect the power house already belongs to the company. It can thus be seen that the possibilities of development of traffic both on the new line and the old are very great.

[621 .31]

THE WATER POWERS OF THE RHINE NEAR LAUFENBURG.

Figs. 1 to 13, p. 641 to 645.

(*Engineering.*)

For some fifteen years, negotiations have been in progress with reference to the development of the water-powers of the Rhine near Laufenburg, where this river is the boundary between Germany (grand duchy of Baden) and Switzerland (canton Aargau). The well-known electrical engineering firm, Messrs. *Felten & Guilleaume-Lahmeyerwerke Actien-Gesellschaft,* of Mulheim-on-the-Rhine, together with a Swiss company — the *Schweizerische Druckluft & Elektrizitäts-Gesellschaft,* of Berne — have now succeeded in obtaining a concession for the utilisation of these water-powers.

At Laufenburg, situated about 35 kilometres (22 miles) from Basle, on the route to Constance, the river Rhine forces its way through a natural barrier of gneiss and granite, with a fall of about 3 metres (10 feet). The waters then rush through a series of rapids extending over a distance of 1 kilometre (0.6 mile). The configuration of the banks — which above and below Laufenburg are steep and high — permits of the river being dammed up some 9 to 10 metres (29 ft. 6 in. to 33 feet) above the normal height. During low-water period, the water supply is at least 260 cubic metres (9,180 cubic feet), while in times of flood, it may rise up to 5,000 cubic metres (176,600 cubic feet) per second. With a head of water varying from 9 to 11 metres (29 ft. 6 in. to 36 feet), the projected power plant will develop about 50,000 horse-power during ten months out of the twelve, 30,000 horse-power being available all the year round. It will, therefore, be one of the most important water-power plants on the European Continent.

The two companies had been working separately for several years, but finally it was agreed to apply jointly for the concession of the project worked out by Mr. S. Z. de Ferranti, of London, and which had already been laid before the authorities by Messrs. Felten and Guilleaume. Mr. Ferranti had investigated the possibilities of the Laufenburg Falls in the year 1890, and had been so favourably impressed that he applied for a concession for their utilisation. Preliminary surveys were made at the time and lodged with the authorities, and later on, Mr. H. W. Kolle, now of the Babcock & Wilcox Company, superintended the making of complete plans of the river on Mr. Ferranti's behalf. The abandoned project of the Swiss company was the work of Mr. A. Trautweiler, of Strassburg. It provided for a masonry dam crossing the Rhine above the bridge at Laufenburg, and for two tunnels to conduct the water through the rock on which the town is built. The power-house was to be located at the outflow of the tunnels just below Laufenburg, where the series of rapids referred to above commences. This scheme would, however, not have allowed of utilising the water powers to their full extent, as the Ferranti project does. The idea of the latter is to concentrate the power, which is now allowed to run waste through the "Laufen" fall and the rapids, shown in figures 1 and 2, at one point about 1,200 (metres (0·75 mile) below Laufenburg, where, as figure 3 shows, a weir and the power-house are to be erected across the river. For this purpose, the section of the bed of the river will be enlarged by blasting the barrier of gneiss over which the water falls at Laufenburg, and removing large quantities of rock from the steep banks that straighten the course of the river between the town and the locality of the power-plant. That part of the river will, therefore, assume the nature of a canal, and there will be no necessity for excavating special canals for head-and-tail race. The thundering and foaming waterfall and rapids, shown in figures 1 and 2, will disappear, and be replaced by a smooth and still expanse of water, presenting the appearance of a small lake. At Laufenburg, on the Swiss side, and Kleinlaufenburg, on the German side, retaining-walls will be erected to protect the lower parts of certain houses and gardens against high water. Various sections through the river-bed are shown in figures 4 to 8, which also indicate the amount of excavation required at different places. The points at which the sections are taken are shown in figure 3. A section through the power-house is given in figure 9, and figures 10, 11 and 12 show the arrangement of the sluices. Proceeding from the right bank to the left, the disposition of the water-power plant will be as follows: firstly, there will be a lock 30 metres (98 ft. 5 in.) long and 9 metres (29 ft. 6 in.) wide, then a dam with three piers and four openings, with large hollow iron gates (Stoney sluice-gates), of which the first is 20 metres (65 ft. 7 in.) wide and 12·5 metres (41 feet) high, the secondly, — *i. e.*, the main gate — 20 metres by 17·5 metres (65 ft. 7 in. by 57 ft. 5 in.), and the third and fourth each 14·5 metres by 12·5 metres (47 ft. 7 in. by 41 feet). These sluice-gates will be operated by hydraulic pressure, the water being raised to a pressure of 120 atmospheres in a special pumping station inside the turbine building, and conducted to the dam by a double pipe-line. To avoid unnecessary height of construction, the hydraulic cylinders for operating the gates are placed inside the latter, and the water pressure enters the cylinders by a hole drilled through the centre of the ram. The gate may be raised 1 metre (3 ft. 3 $^3/_8$ in.) above high-water level, and the upper 2 metres (6 ft. 6 $^3/_4$ in.) of each door may be lifted alone, in order that the floating matter which comes down the river at certain seasons, may be washed over the dam. The power-house, which joins the dam at an angle, will occupy the left side of the river. For greater stability, the piers and abutments of the dam will be joined up by stone arches, so as to form a viaduct. Floating booms will be provided in front of the power-house, to keep off driftwood and other floating matter. To allow the salmon and other fish, to which the high dam would be an insuperable obstacle, to continue their course, special fish-passages will be cut into the rock on either side of the river. The power-house will contain ten turbines of 5,000 horse-power units, two exciter turbines (1,500 horse-power units), and small turbines for the pumping station; also the whole electrical equipment — *viz.*, dynamos, transformers, switchboards, electric travelling-cranes, etc. The turbines will be of Francis type, with three wheels. Two of these wheels discharge into a concrete pipe, and the lowest directly into the pit. Each

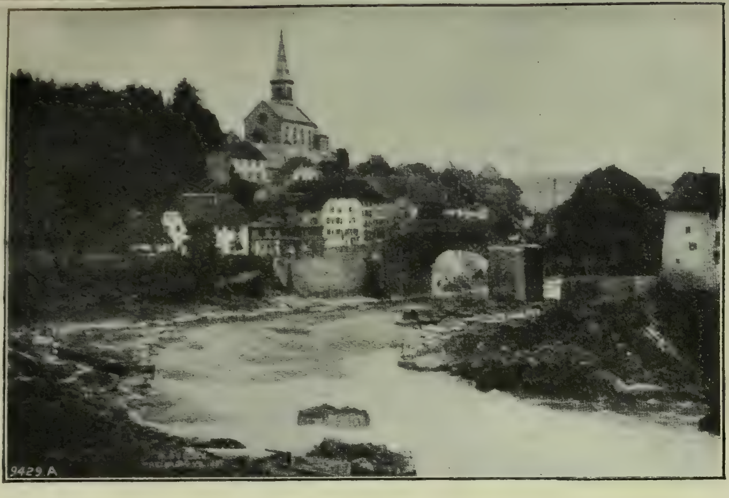


Fig. 1. — View of rapids, looking up stream from near Baden station.

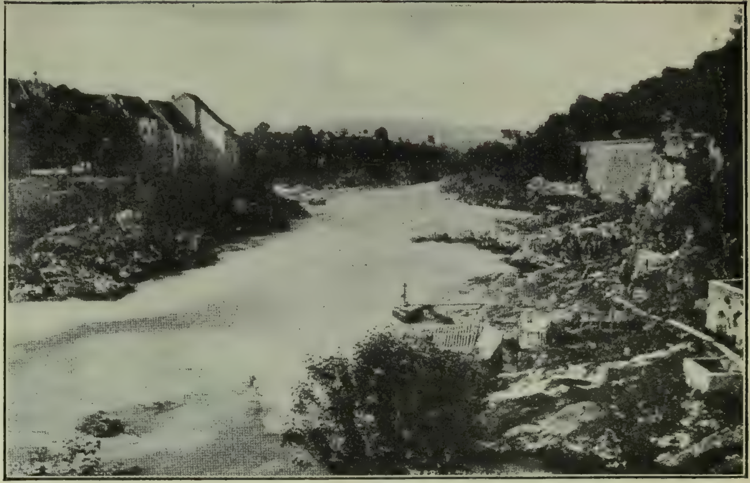
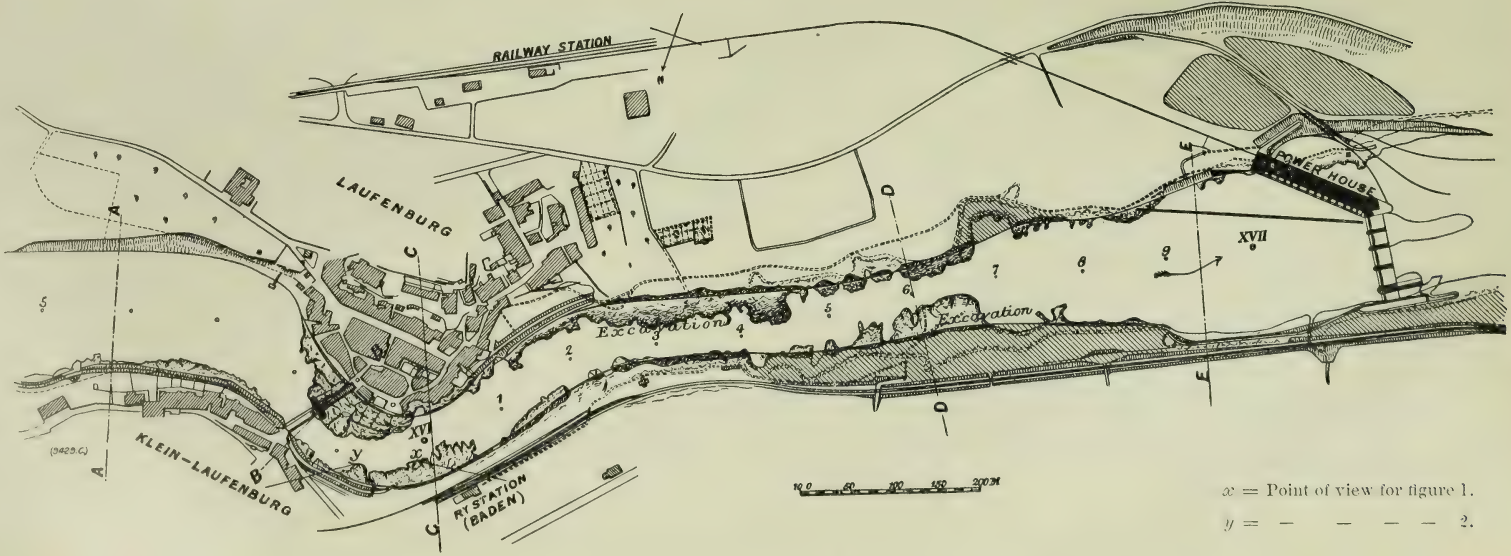


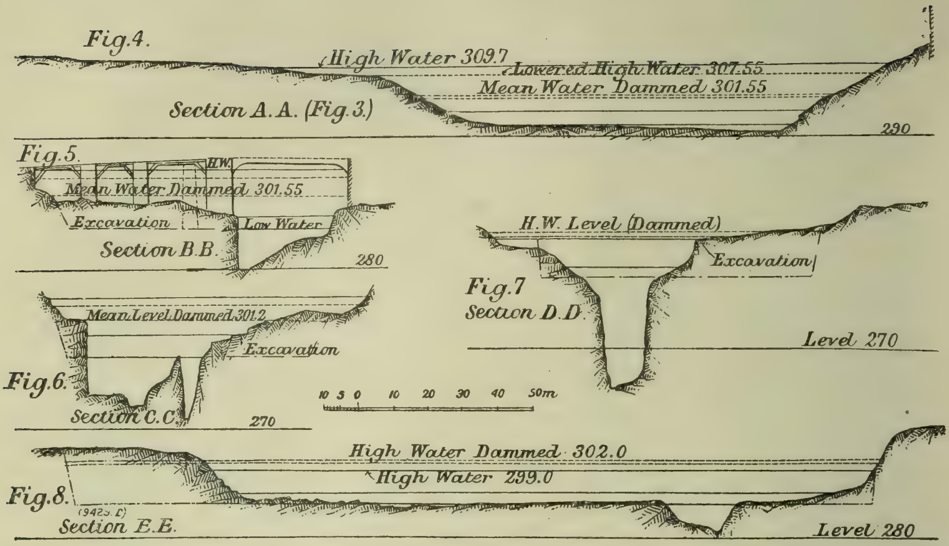
Fig. 2. — View of river, looking down stream from opposite Laufenburg.



x = Point of view for figure 1.

y = — — — — 2.

Fig. 3. — Plan of Laufenburg falls, showing situation of new power-house.



Figs. 4 to 8.

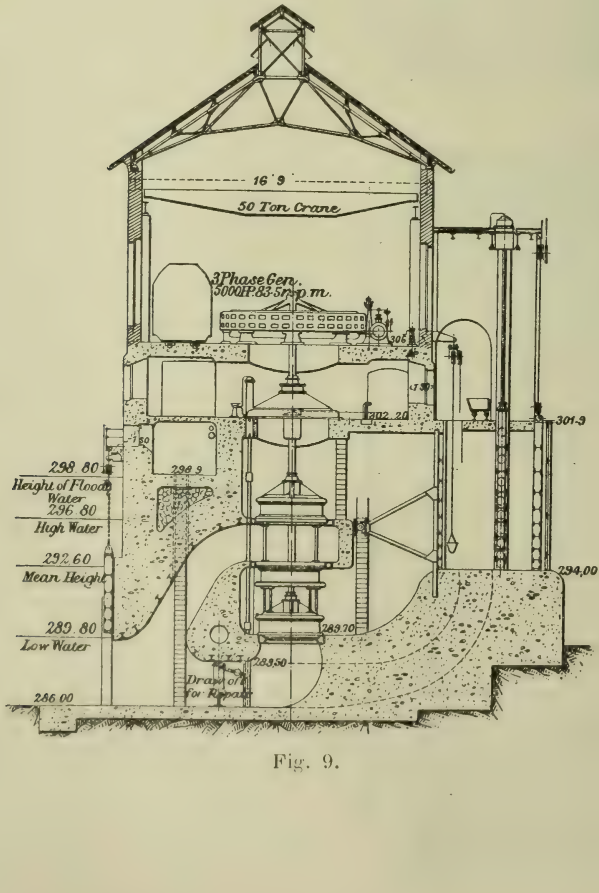
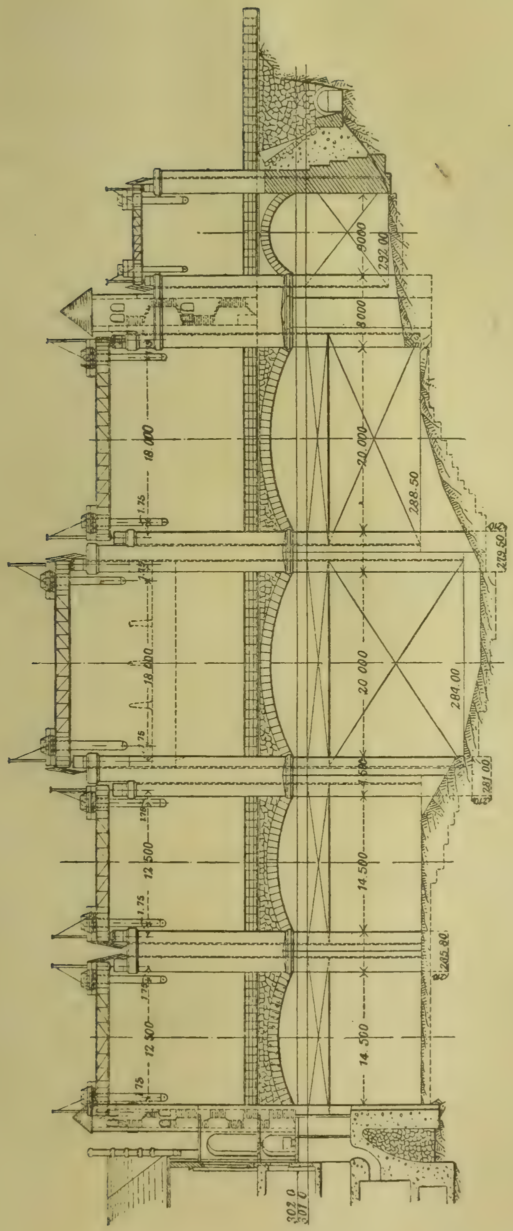


Fig. 9.


9000
292.00
8000
18.000
1.75
20.000
288.50
279.50
18.000
20.000
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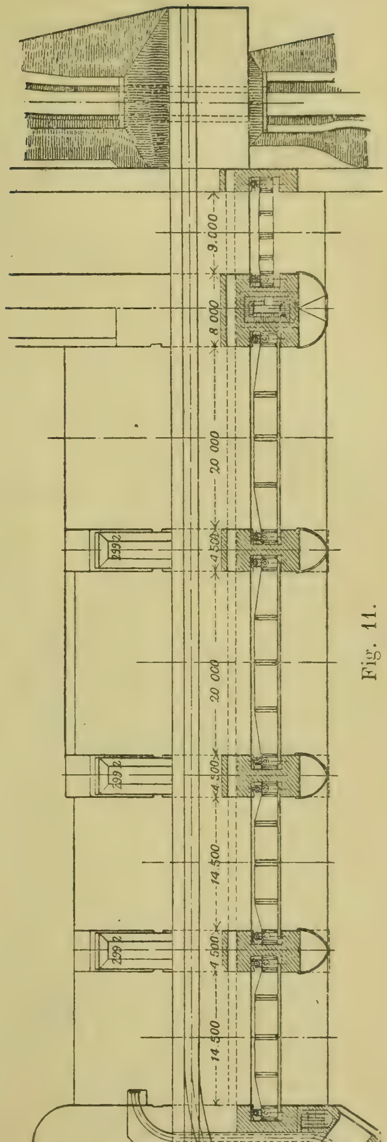
302.0
301.0

Fig. 10.


9.000
8.000
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299.2
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299.2
14.500
4.500
299.2
14.500

Fig. 11.

turbine-chamber can be closed in front by an hydraulic sluice-gate; to close the chamber from the pit side there are movable gates, worked by hand-winches.

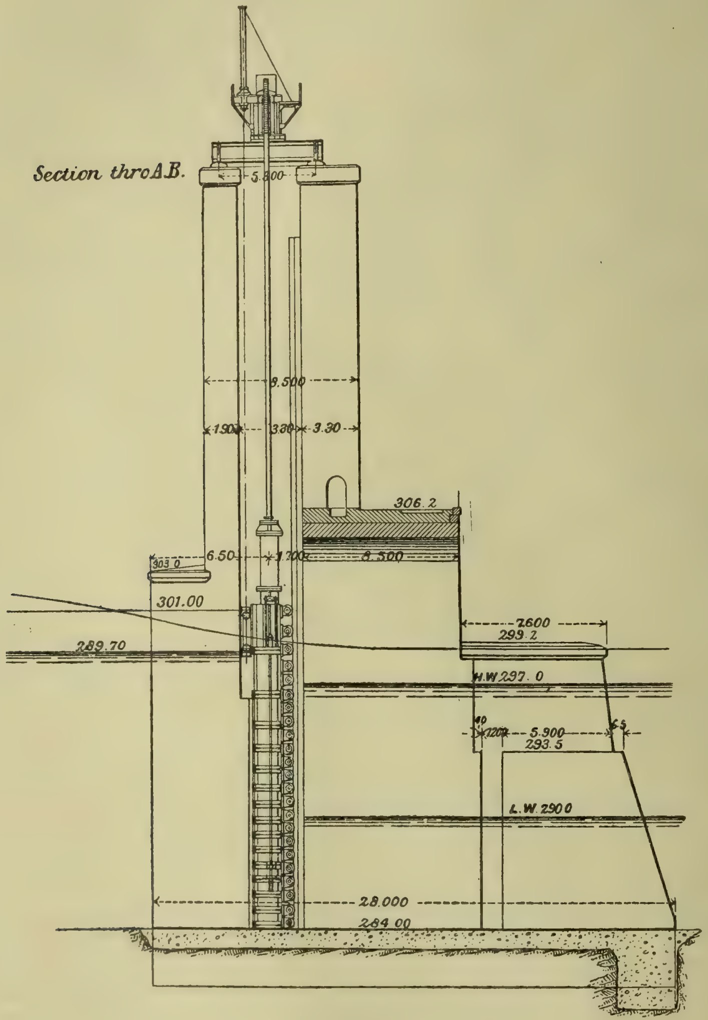

Fig. 12.

When the chamber is closed from both sides, it may be emptied by pumps provided for this purpose. There is a pair of centrifugal pumps connected to one general pipe, and this pipe is connected to every turbine-chamber by means of a stop-valve.

In front of the turbine-chambers, there is one wide and one fine screen. These screens can be cleaned either by hand or by machinery, and washed by the following method : the front gate of the chamber being closed, and the separating gates to the next chambers opened, in front of the gate a trap-door, normally closing a channel leading directly to the pit, is opened, so that the water rushes in the opposite direction through the screen, and washes all matters from it into the pit.

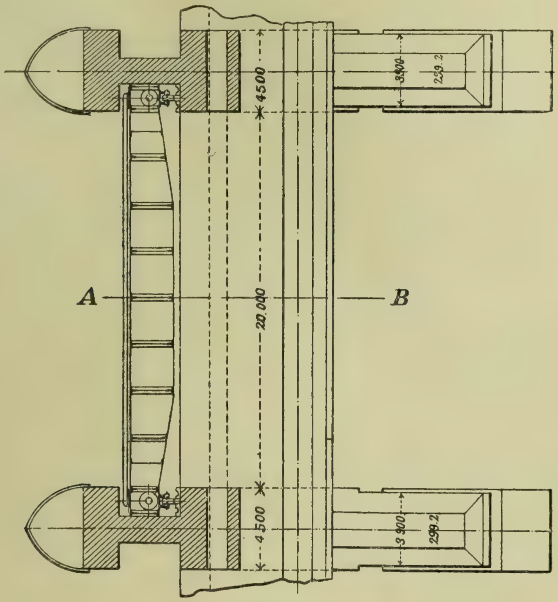

Fig. 13.

The electric energy will be partly transmitted to consumers in the south of Baden and the north of Switzerland, and partly used for electro-chemical purposes. Mr. H. E. Gruner, of Basle, is the resident hydraulic engineer of the undertaking, and has added a number of plans to those originally made, many of them to meet the requirements of the two governments concerned — namely, Switzerland and Germany. The great difficulties caused by the water-power being on the frontiers of these two countries, and certain other reasons, have been responsible for the long interval which has elapsed since the inception of the scheme, the concession having only been granted a few months ago after sixteen years of work. Much of the trouble with the authorities in the early days was due to the fact that the scheme was novel in its engineering features, and lacked the usual canal to or from the turbines, although the early design has since been abundantly justified by the success of similar arrangements. The time necessary for carrying out the scheme will be from four to five years. Operations will in all probability be commenced during the present year, and we hope, in due course, to deal with the works in greater detail.

MISCELLANEOUS INFORMATION

621 .132.5 & 621 .134.5]

1. — Santa Fe type Baldwin locomotive with superheater, Pittsburg, Shawmut & Northern Railway.

Figs. 1 to 5, pp. 647 and 649.

(*Railway and Engineering Review.*)

In the February 2 issue of the *Railway and Engineering Review* we gave an illustrated description of a Baldwin Santa Fe type simple locomotive which had been in service for over a year on the Atchison, Topeka & Santa Fe Railway, with a Badwin design of superheather and steam pressures considerably lower than it has been customary to use during the past decade. As a result of the results obtained from this experimental locomotive, the Baldwin Locomotive Works has built a locomotive for the Pittsburg, Shawmut & Northern Railway which embodies certain perfections of the idea. This locomotive has the distinction of being the 30,000th locomotive constructed by the Baldwin Locomotive Works, and we are now enabled to present herewith the particulars of a development which gives promise of greatly popularizing superheating.

The general appearance of the locomotive is shown in figure 1, the general construction features in figure 2, and the superheating arrangement in detail in figures 3 to 5. The general dimensions and ratios are as follows :

Cylinders	28 × 32 inches.
Boiler, diameter	78 $^{3}/_{4}$ —
Thickness of sheets	$^{7}/_{8}$ and $^{15}/_{16}$ inch.
Working pressure	160 lb.
Staying	Radial.
Fire-box :	
Length	108 inches.
Width	78 —
Depth, front	80 $^{1}/_{4}$ —
Depth, back	78 $^{1}/_{4}$ —
Thickness of sheets, sides	$^{3}/_{8}$ inch.
Back	$^{3}/_{8}$ —
Crown	$^{3}/_{8}$ —
Tube	$^{9}/_{16}$ —
Water space, front	4 $^{1}/_{2}$ inches.
Sides	5 —
Back	4 —

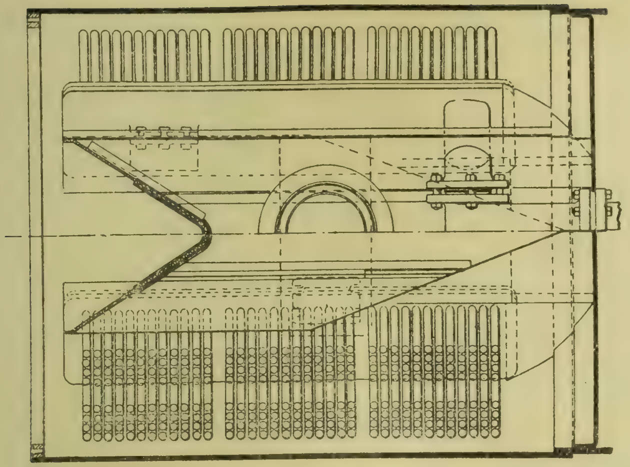

Fig. 3.

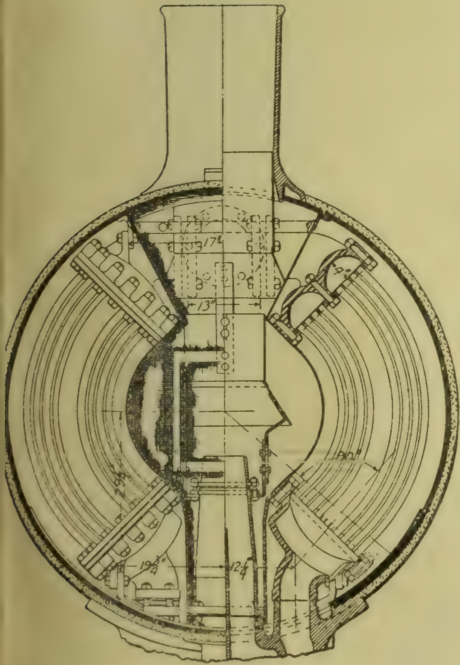

Fig. 4.

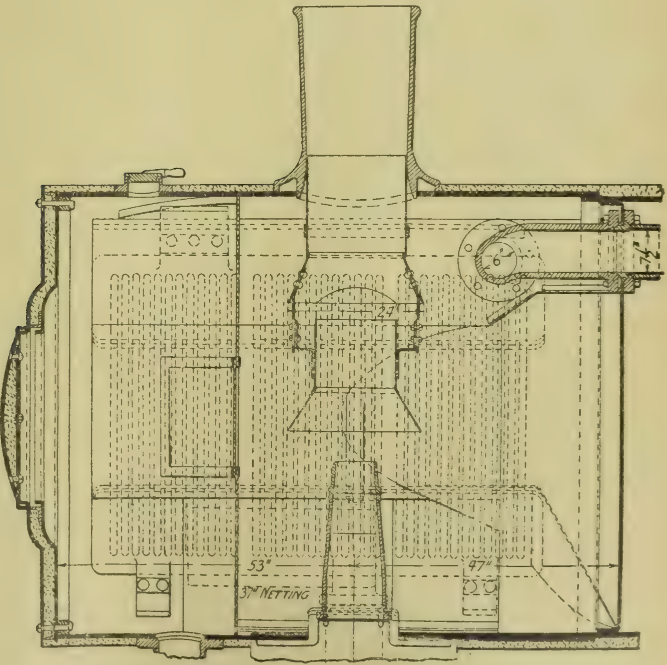

Fig. 5.

gs. 3 to 5. — Baldwin freight locomotive with superheater, Pittsburg, Shawmut & Northern Railway. — Superheater arrangement.

Tubes : 391 ($2\,^1/_4$ inches)	20 feet.
Heating surface : fire-box	210 square feet.
Tubes	4,586 — —
Total	4,796 — —
Grate area	58·5 — —
Driving wheels	57 inches.
Journals	Main, 11 × 12 inches; other, 10 × 12 inches.
Engine truck wheels (front)	$29\,^1/_4$ —
Back	40 —
Wheel base: rigid	19 ft. 9 in.
Total engine	35 ft. 11 in.
— — and tender	67 ft. $4\,^1/_2$ in.
Weight : on driving wheels	235,000 lb.
Total engine	288,000 lb.
— — and tender	450,000 lb.
Tank : 8,500 gallons	14 tons.

RATIOS.

$\frac{\text{Weight on drivers}}{\text{Tractive effort}}$	3·92 or 25·2 per cent.
$\frac{\text{Total weight}}{\text{T. E.}}$	4·8 or 20·8 per cent.
$\frac{\text{T. E diameter of drivers}}{\text{Heating surface}}$	713 (B. D.)
$\frac{\text{Tube H. S.}}{\sqrt{\text{tube length}}} + \text{F. B. H. S.}$	1,235 square feet.
$\frac{\text{Total H. S.}}{\text{Grate area}}$	82 — —
$\frac{\text{F. B. H. S.}}{\text{Total H. S.}}$	4·4 per cent.
$\frac{\text{Weight on drivers}}{\text{H. S.}}$	49 lb.
$\frac{\text{Total weight}}{\text{H. S.}}$	60 lb.
Volume of both cylinders	22·8 cubic feet.
$\frac{\text{Total H. S.}}{\text{Cyl. vol.}}$	210·3 square feet.
$\frac{\text{G. A.}}{\text{Cyl. vol.}}$	2·57 — —

As the chief point of interest centers about the superheater, we will concern ourselves with that alone. It will be remembered of our mentioned description of the locomotive put in service on the Santa Fe, that boiler pressures of from 130 to 150 lb. were used, and that the superheating surface amounted to 266 square feet in each “ superheating steam pipe ”, or 532 square feet in all. Further, that, on each side, the steam had about 14 feet of passage (in three “ convolutions ”) through the superheating tubes. In the present instance, the superheating surface has been increased to 381 square feet (on each side) and a differently arranged grouping has increased the length of steam passage through them to about 27 feet in fixe “ convolutions ”. Also the gas deflecting wings have been changed

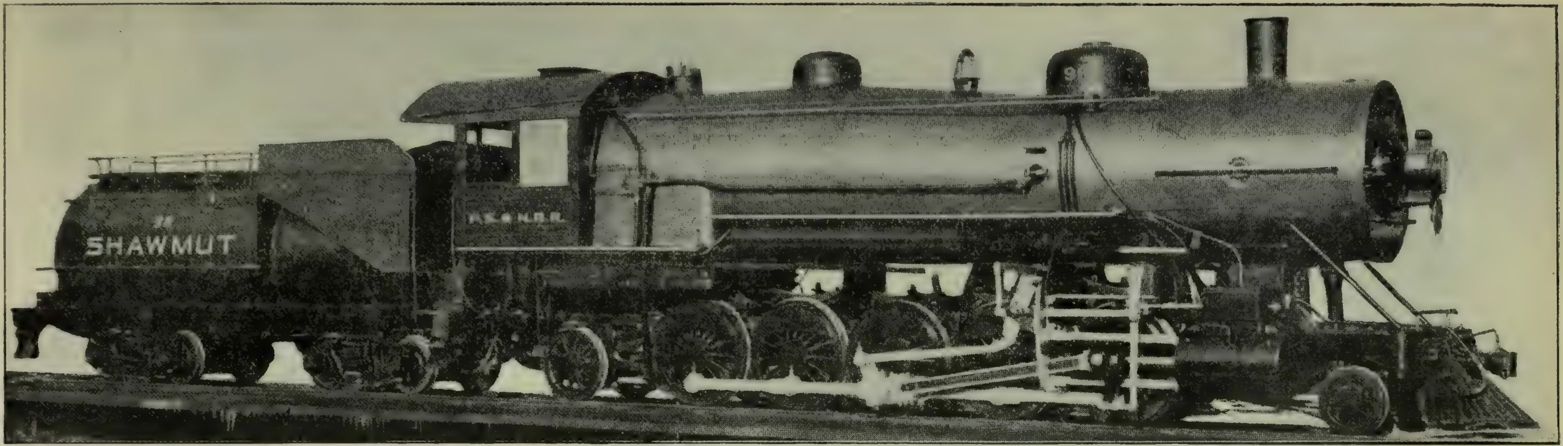

Fig. 1. — Baldwin freight locomotive with superheater, Pittsburg, Shawmut & Northern Railway

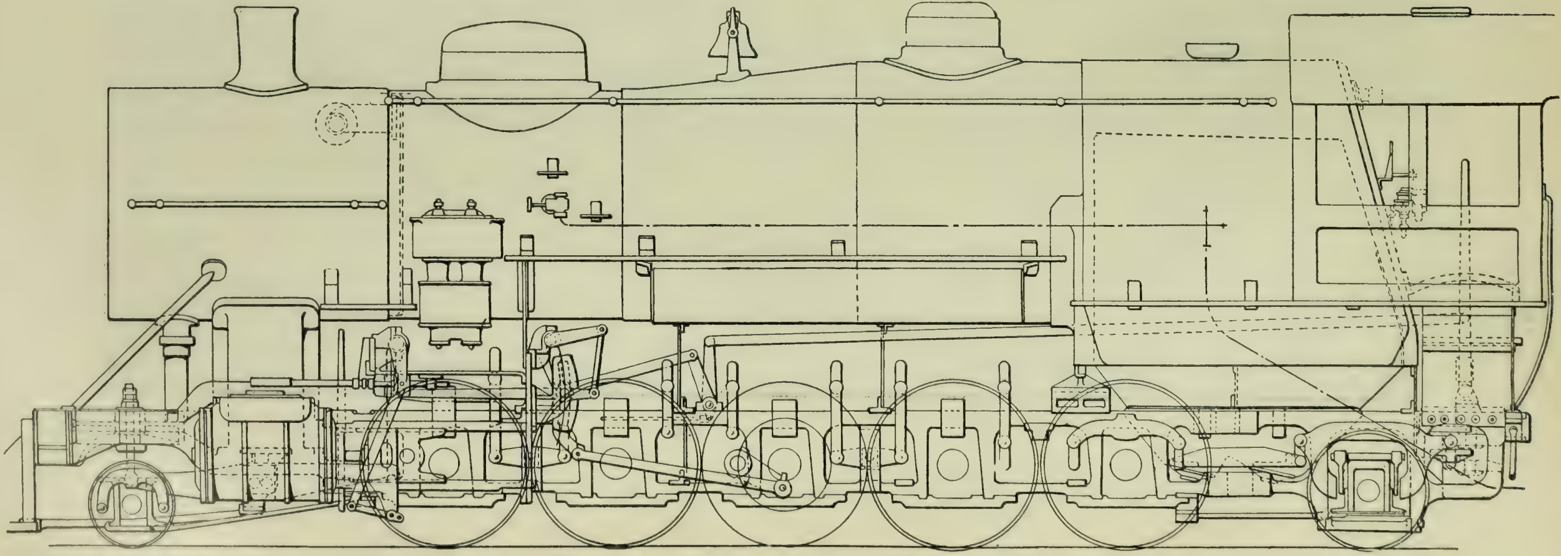

Fig. 2. — Baldwin freight locomotive with superheater, Pittsburg, Shawmut & Northern Railway. — General constructive features.

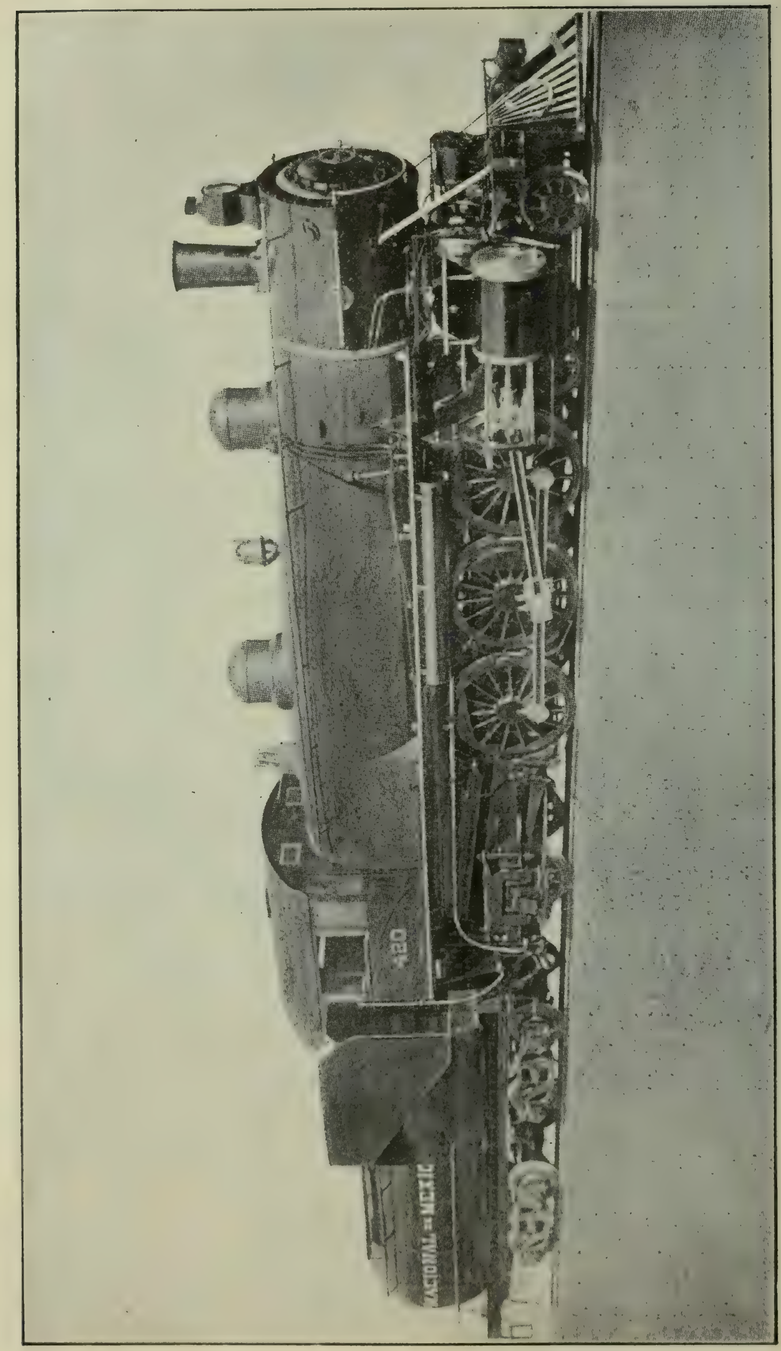

Fig. 6. — Balanced compound for the Mexican National.

from a permissible swinging open, to a rigidly fastened operative condition. A steam pressure of 160 lb. is used.

Without dwelling further on these matters of improvement, we will call attention solely to the present design as exhibited in figures 3 to 5. In this it will be noticed that no change is required in the construction of the boiler in order to accomodate the superheater, which merely takes the place of the steam pipes in the smoke box. The superheater consists of an upper and lower drum for each cylinder, these drums being connected by 288-1 $^1/_4$ inch curving rows of tubes, which contain 352 square feet of heating surface and follow the contour of the smoke box shell. The drums are cast steel and contain 29 square feet of heating surface each. The tubes are expanded into tube plates, which are bolted to the drums; copper gaskets being provided in order to make the joints tight. The tubes are divided into separate groups, through which the steam is successively passed on its way to the cylinders, passing down the rear exterior group of tubes first, then up through the rear interior group, then down again through the center interior group, then up through the center exterior group, and then finally down through both the exterior and interior forward groups to the saddle steam passage. The superheating is thus obtained entirely from the waste gases, and these are utilized as fully as possible. The heated gases are compelled to circulate among the superheater tubes by means of suitably arranged deflecting plates. The illustration clearly shows this arrangement; also the position of the netting and petticoat plates.

On this latter point, we wonder where front end drafting specialists and deflector plate experts will " get off ". It is a fact that there has been little trouble found in properly drafting the fire with these radically different-from-the-usual arrangements. Yet the American fetich, the deflector plate, as a functional drafting device, has been abandoned in favor of the petticoat pipe, which procedure has been advocated by the *Railway and Engineering Review* for years. The area of netting gives a first impression of being very small, but an observance of its angled arrangement will show it to really contain almost double the amount of practical area usually found in our front ends. The whole proposition of superheating, of using the waste gases for superheating purposes, of utilizing the waste gases at all, of enabling the use of low boiler pressure by superheating through this utilization of waste gases, of avoiding the evil results of foaming by this means, of avoiding lubricating difficulties by these reasonable degrees of heats put into the cylinders, of getting rid of the ordinary deflector plate, all appears an exploitation of the front and along lines wkick are as simple as sound — in other words, it is one of those strides forward in locomotive development which are so obvious after the other fellow brought it about, that the rest of us all wonder why we did not think of it before.

[621 .132.3]

2. — Compound for the Mexican National.

Fig. 6, p. 650.

(*Railway and Locomotive Engineering.*)

The National Railway of Mexico has recently received a balanced compound Pacific type locomotive from the Baldwin Locomotive Works. The principal features of the designs are shown in our illustration (fig. 6). The cylinders of this engine are all in the same horizontal plane; therefore, as all the pistons are connected to the second pair of driving wheels, the inside main rods have been bifurcated in order to clear the leading axle. The front end of the rod is provided with lips which bear against the body of the stub, thus relieving the stub bolts of shear. The wrist pin brass is split and is provided with a wedge adjustment. The back stub is fitted with the usual strap and key.

The cylinders are 17 and 28 by 28 inches, and with a boiler pressure of 200 lb., and driving wheels of 67 inches in diameter, the calculated tractive effort amounts to 35,720 lb. With a weight of 147,000 lb. on the drivers, the factor of adhesion is 4·11. Each pair of cylinders is provided with one piston valve, which is driven by the Stephenson link motion. The eccentrics are placed one the third driving axle. The valve rods are necessarily long, supported at two intermediate points and are provided with knuckle joints. The arrangement of valve gear with eccentrics on one axle and driving cranks on another, is sometimes spoken of as tandem connected valve gear.

The crank axle is built up of seven pieces. The crank cheeks are circular and the central member, in the built up arrangement, is of cast steel. The frame centers are 44 inches apart, but between the main driving wheels, this is increased to 45 $^1/_2$ inches, in order to secure a journal 10 inches long between the crank cheek and the face of the wheel hub. The Rushton trailing truck with outside journals is used on this engine. In this truck, the axle box is rigidly held between the pedestals, and the cast steel equalizer, or spring seat, is suspended directly on spring links. The bearings for these spring links are bolted to a supplemental frame, which is secured to the main frame by means of cast steel brackets. The driving wheel base of the engine is 12 feet, and the total is 33 ft. 11 in. With tender added, the entire wheel base becomes 62 ft. 11 in. The engine itself weighs 227,340 lb, the forward truck carries 45,300 lb., and the rear truck 35,000 lb. The weight of engine and tender together is 370,000 lb.

The boiler is of the wagon top type, with the taper course forward of the dome. The firebox is 113 $^1/_2$ × 66 $^1/_4$ inches and has a grate area of 52·1 square feet. The heating surface is made up of 186 square feet in the firebox, 3,527 in the tubes, giving a total of 3,713 square feet, and the ratio of grate area to heating surface is as 1 to 67.

The grate slopes down toward the front, as the firebox is 75 $^3/_4$ inches deep at the front and 61 $^3/_4$ inches at the back. The crown sheet and roof sheet slope upward to the front, and as the second course is taper, the dome stands on the highest part of the boiler and is thus designed to secure dry steam for the throttle.

The tender is made with a cylindrical or Vanderbilt tank, which is carried on the usual structural steel frame and arch bar trucks. The water capacity of the tank is 7,500 gallons and the fuel space holds 12 tons of coal. Some of the principal dimensions are appended for reference :

Boiler : Material, steel, diameter, 70 inches; thickness of sheets, $^{11}/_{16}$ and $^3/_4$ inch; fuel, solf coal; staying, radial.

Fire-box : Material, steel; thickness of sheets, sides, $^3/_8$ inch; thickness of sheets, back, $^3/_8$ inch; thickness of sheets, crown, $^3/_8$ inch; thickness of sheets, tube, $^1/_2$ inch.

Water space : Front, 4 $^1/_2$ inches; sides, 4 inches; back, 4 inches.

Tubes : Wire gauge, No. 12; number, 301; diameter, 2 $^1/_4$ inches; length, 20 feet.

Driving wheels : Journals, main, 11 × 10 inches; journals, others, 9 × 12 inches.

Engine truck wheels : Diameter, front, 30 inches; journals, 6 × 10 inches; diameter, back, 48 inches; journals, 8 × 14 inches.

Tender : Wheels, diameter, 33 inches; journals, 5 1/2 × 10 inches; service, passenger.

[**621** .154.3]

3. — Progress in superheating.

(*Railway Age.*)

The last reports regarding the application of superheaters to locomotives show that in Europe there are now 1,600 engines so equipped, principally on the Prussian State Railways. In America, 260 locomotives with superheaters are in use or under contract; 200 of these are on the Canadian Pacific, 150 in actual use and 50 under construction. The greater number of superheaters in use in the United States and Canada were applied by the American Locomotive Works, and have steam coils placed in large firetubes, which replace some of the regular boiler tubes in the upper courses.

The Baldwin Locomotive Works have designed a smokebox superheater which utilizes the waste gases only, and it has been applied to one large ten-coupled engine on the Santa Fe and to an engine or similar type for the Pittsburg, Shawmut & Northern (1). The engine has cylinders 28 by 32 inches and 57-inch drivers and with 160 pounds boiler pressure will develop a tractive power of 60,000 pounds. The Baldwin company in its work on superheaters, thus far is content to use a degress of superheat which simply insures dry steam, and does not produce an economy much beyond that due to the prevention of condensation. The experiments made on the Santa Fe with this apparatus, show a superheat of only 30 or 40°, and the saving in steam per horsepower hour due to this slight superheating, as compared with saturated steam, does not amount to more than 5 per cent. Drying the steam where there is the tendency to foam in an alkali water district, however, has advantages which extend beyond mere economy of fuel, as they contribute largely to the successful operation of the engine. The Baldwin company in its superheater practice, is also following the suggestion of Herr Garbe in using large cylinders and lower boiler pressure.

In the superheater of the Pittsburg, Shawmut & Northern Railway engine, a large amount of heating surface is provided, 381 square feet for each cylinder or a total of 762 square feet. This is about twice as much surface as is found in the firetube heaters of Schmidt or Cole. The firetube is much more efficient as a heater, as one-half the surface will produce a superheating of 200°, or four times that of the smokebox heater subjected to waste gases only. With superheat of 200° Fahr. an economy of 25 per cent in the use of steam should be obtained, but various difficulties in practice have thus far prevented the use of such high temperatures with superheaters on locomotives in this country.

The tests of superheaters on the Canadian Pacific reported to the American Railway Master Mechanics' Association, show on average of only 100° Fahr. for one class and about 50° Fahr. for the other, but with the improved superheaters now being applied to locomotives for that road, it is expected that much higher temperatures will be obtained. The difficulty with the firetube heaters is that on account of the restricted space for the passage of the gases the tubes containing the steam coils gradually become clogged, and while good results are obtained when the coils are perfectly clear, there is a gradual decrease in their efficiency until they are again cleaned.

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(1) Vide *Bulletin of the Railway Congress*, No. 6, June, 1907, p. 646.

In the test with a Delaware, Lackawanna & Western passenger engine using anthracite coal, it was found that the heating surface did not become coated with soot or clogged with cinders, but even under such favorable conditions, the average superheat while using steam was only 107° Fahr., and the saving in coal about 18 per cent. Again, the test of the Cole superheater on the Boston & Maine with bituminous coal, showed an average superheat of a little less than 100°, and a gain in ton-miles per pound of coal of about 15 per cent. In Germany, the average superheat on locomotives is 150° Fahr. In the tests of the locomotives with the Pielock superheater at the St. Louis exposition, the superheating obtained was 160 to 190° Fahr. and with this device it is possible to obtain superheat up to 200 or 300° Fahr.

When superheated steam is used, there is the further difficulty with the lubrication of the valves and cylinders. The reports of the tests on the Lackawanna, in which only a little over 100° of superheat was used, and where the engine was operated most of the time at short cut-off, state that a large excess of lubricating oil was required for the valves and cylinders, and even then they were found to wear rapidly and required frequent renewals. When valves are not properly lubricated, there is also excessive wear in all parts of the valve motion, and under such conditions, there is likely to be as much loss in the use of steam as is gained by superheating. It has been suggested from the start, that forced lubrication would be necessary with the use of superheated steam, but we are not informed of any such lubricator having been successfully developed thus far for locomotives and dependence is had on the regular sight feed lubricators.

On the Canadian Pacific, where the Schmidt superheater was used and steam was superheated to a temperature of 700° Fahr. it was found that ordinary valve oil was not suitable and the valve rod packings would melt out. In Germany, where higher degrees of superheat are used, Mr. Schmidt has designed a special piston valve and valve bushing which takes care automatically of the expansion due to high temperature, but in this country, no effort appears to have been made to improve the piston valve to make it more suitable for such conditions. There is little doubt that these difficulties connected with the use of a high degree of superheating on locomotives, have prevented more rapid progress in the application of superheaters to locomotives in this country, and it is probably for this reason that the Baldwin company in its practice has not attempted to design a superheater for high temperature steam.

In order to obtain the economies possible with real superheating, which would use a superheat of 200 or 300° Fahr., it will be necessary to give more attention to the question of lubrication, to the design of superheating fixtures which will not be easily clogged, and to the development of some system of taking care of them in service, so that they will be cleaned regularly. The history of the use or Serve tubes on locomotives in France, is suggestive in this connection. In order to obtain the proper efficiency due to the principle, it is necessary to blow them out regularly after every trip in order to keep the heating surface clean and free from soot. The work connected with the cleaning of the tubes is rather disagreeable, and we understand that so much difficulty has been experienced in having men to attend to their duty in this kind of work, that the practice of using Serve tubes in France is rather on the decline. It is quite possible that similar difficulties will be found in connection with those forms of superheaters which use firetubes, so that some other form of superheather will have to be devised.

The Pielock superheather does not appear to be subject to this objection, as all the regular tubes of the boiler are free and can be easily cleaned, while the degree of superheat to be obtained from this type is equal to that of any other thus far designed. With a superheater built somewhat on the Pielock principle, a piston valve with packings and bushings designed for high temperature steam, and forced lubrication using a high fire test lubricant, the prospect for a more general application of superheaters to locomotives in the United States would be more encouraging.

[621 .33 (.42)]

4. — Metropolitan District Railway.

(*Railway Gazette.*)

The year 1906 may be regarded as the starting point of the transformed District Railway. It is needless to indicate the remarkable improvement in the status and condition of the property, as everyone is aware of the great change that has been effected. The essential thing to be borne in mind is that the company is now in a position to handle a greatly increased traffic without additional expenditure. Possibly a certain amount of economy in comparison with the expenditures of 1906 may be secured, but not very much can be expected in this direction. The company is laying down harder rails and if the life of the new rails is longer than that of the old ones, the work or re-laying will be reduced, and the expenditure under the heading of maintenance of way will be curtailed. But, generally speaking, no appreciable additional economy may be expected. By this we do not mean that greater economy will not be secured in proportion to the traffic. We mean that the total expenditure is not likely to be appreciably reduced. On the other hand, there will not be much increase in expenditure no matter how great the growth of traffic should be, any expansion in the gross earnings is likely to be almost entirely net gain. In taking stock of the results obtained in the second half of 1906, we have to recollect the general conditions affecting the company's working. Competition for the passenger traffic of London is just now very fierce. The number of motor omnibuses has enormously increased, and the fares charged for relatively quick service by road are undoubtedly low. Practically, all the railways of London have suffered from the new competitor. The District has been the most successful in increasing its receipts and in adding to its traffic. For the half-year, the expansion in its gross receipts was £12,337, or 6 per cent. As Sir George Gibb was careful to explain to the shareholders, £10,000 of this increase arose from the higher fares charged in the last four months of the half-year. If allowance be made for the receipts from the higher fares, the company still had a small expansion in its traffic and in its earnings, whereas the Central London, the Metropolitan and the North London all suffered decreases. The Metropolitan's decrease in gross receipts was as much as £100,468, but the greater portion of this decline was due to causes other than the loss of local traffic. The chairman of the Metropolitan acknowledged, however, that the local traffic on the Metropolitan line proper declined about £7,700, mainly owing to the competition of the motor omnibuses and the abolition of their second-class fares. The gross earnings of the Central London Railway for the half-year showed a decline of £7,779, or 4·4 per cent, and those of the North London also showed small diminution. Thus it is evident that the District fared better than its neighbours in the matter of traffic, and it is also evident that the advance in fares, which the chairman explained, averaged only a farthing per ordinary passenger, has been fully justified by the results.

No effort has been spared to secure efficient and economical working. Great attention has been paid to the working of the trains, and as a result, the company was able to obtain its increase of 7·2 per cent in passenger receipts, with a diminution of 10·9 per cent in the car-mileage on the District Railway only, and of as much as 17·4 per cent decrease in the total car-mileage, including mileage, on joint and foreign lines. The following table shows the saving in car-mileage :

	December half, 1906.	December half, 1905.	Increase or decrease	
	£	£	£	Per cent.
Passenger receipts	201,036	187,452	+ 13,584	+ 7·2
	Miles.	Miles.	Miles.	
Car-mileage (District Railway only) . .	5,195,487	5,836,474	— 640,987	— 10·9
— (including mileage on joint lines and foreign lines) . .	7,048,962	8,532,587	— 1,483,625	— 17·4
Earnings per car-mile (District Railway only)	9·24*d.*	7·71*d.*	+ 1·53*d.*	+ 19·8
Earnigs per car-mile (including mileage on joint lines and foreign lines)	6·84*d.*	5·25*d.*	+ 1·59*d.*	+ 30·2

It will, of course, be realised that the reduction in the number of car-miles has not affected the efficiency of the service rendered ; it has been effected by curtailing the number of cars per train. This will be evident from the following statement :

	December half, 1906.	December half, 1905.	Increase or decrease.		
District Railway only :					
Car-mileage.	5,195,487	5,836,474	— 640,987	— 10·9	per cent.
Train-mileage	1,179,495	1,031,103	+ 148,392	+ 14·3	—
Cars per train (No.)	4·40	5·56	— 1·26	— 22·2	—
Total, including mileage on joint lines and foreign lines :					
Car-mileage.	7,048,962	8,532,587	— 1,483,625	— 17·4	—
Train-mileage	1,623,758	1,402,386	+ 221,372	+ 15·8	—
Cars per train (No.)	4·34	6·08	— 1·74	— 28·6	—

From the above statement, it is evident that the train service has been more frequent, and that the reduction in car-miles has been entirely effected by reducing the cars per train to more reasonable and economical numbers. We have shown that the earnings per car-mile were 6·84*d.* These are the earnings per car-mile after certain deductions have been made from the earnings of the car, in respect of traffic carried on joint lines and foreign lines. Therefore, the total earnings per car-mile are something over 6·84*d.* and something under 9·24*d.* If the earnings per car-mile are about 8*d.*, as they probably are, it is evident that there is plenty of space available for additional passengers without the necessity for any material increase in the car-mileage. The trailer cars of the District Railway seat 52 passengers each and the motor cars 48 passengers. Were we to make no allowance whatever for receipts from workmen, and to assume average earnings of 8*d.* per car-mile from ordinary passengers, it would be evident that the average number of passengers per car-mile is only about eight. In other words, taking the day through, the car loads of passengers represent only about 15 per cent of the carrying capacity provided. Thus, it will be obvious that a very considerable increase in traffic can take place without much additional expense. Doubtless in the rush hours of the morning and evening, additional third-class car-miles will have to be provided from time to time as traffic grows, but during the greater portion of the day, no additional car-mileage will be necessary to deal with very much greater traffic, and the greater portion of any increase in gross receipts will be net profit. No advantage will be gained by discussing the expenditure of the company in a period of transition. A little later on, when matters may be termed normal, an analysis of the expenditure will probably be instructive, both for the purpose of ascertaining the real cost of electric traction when applied to steam railroads, and for the purpose of ascertaining the advantage of electric traction in comparison with steam. The expenditure for the past half-year increased £11,643, and the net earnings showed an increase of only £693. The working results for the six months are appended :

	December half, 1906.	December half, 1905.	Increase or decrease.	
	£	£	£	Per cent.
Gross earnings	215,846	203,510	+ 12,336	+ 6·0
Expenses	155,719	144,076	+ 11,643	+ 8·0
Ratio	(72·15)	(70·79)	+ (1·36)	...
Net earnings	60,127	59,434	+ 693	+ 1·1
Net income	86,991	81,984	+ 5,007	+ 6·1
Fixed interest, rents, etc.	125,476	116,833	+ 8,643	+ 7·4
Dividend on 4 p. c. guaranteed stock	9,375	7,031	+ 2,344	...
Rate per cent	(1 $^1/_2$ p. c.)	(1 $^1/_8$ p. c.)	+ ($^3/_8$ p. c.)	...
Brought forward	...	...	...	...
Balance	*Def.* 47,860*	*Def.* 41,880*	— 5,980	...

Practically, the whole of the additional expenditure has been incurred in increased outlays upon the road and rolling stock. The actual cost of working the traffic has been appreciably reduced. There has been an increase of £15,004 in electric train working, but, on the other hand, the traffic expenses have been curtailed £22,778, and on balance the cost of handling and conveying the traffic has been reduced by £7,774, or by nearly

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(*) Charged to capital account.

7 per cent, for the half-year, in comparison with the December half of last year. The comparison of the details of the expenditure for the half-year is as follows :

	December half, 1906.	December half, 1905.	Increase or decrease.	
	£	£	£	Per cent.
Maintenance of way	26,392	15,055	+ 11,337	+ 75·3
Electric train working	82,776	67,772	+ 15,004	+ 22·1
Repairs and renewals of cars	19,224	8,778	+ 10,446	+ 118·7
Traffic expenses	22,658	45,436	— 22,778	— 50·1
General charges	11,464	11,756	— 292	— 2·5
Law and parliamentary	768	1,635	— 867	— 53·0
Compensation	858	1,015	— 157	— 15·4
Rates and taxes	18,878	17,374	+ 1,504	+ 8·6
Government duty	454	668	— 214	— 32·0
Joint lines and stations	4,349	5,476	— 1,127	— 20·5
Total	187,821	174,965	+ 12,856	+ 7·3
Less work done for other companies	32,102	30,889	+ 1,213	+ 3·9
Total expenditure	155,719	144,076	+ 11,643	+ 8·0

For the purpose of showing the very large growth in the number of passengers carried by the company in recent years, the course of the passenger receipts and the receipts per passenger, we give the following statement :

	Number of passengers.	Season tickets (estimated journeys).	Total passengers.	Passengers receipts.	Receipts per passenger.
1906	59,799,864	3,141,935	62,941,799	£403,315	1·54*d.*
1905	52,961,945	2,989,561	55,951,506	£373,136	1·60*d.*
1904	50,331,397	4,680,855	55,012,252	£366,392	1·60*d.*
1903	48,413,832	5,166,187	53,580,019	£370,323	1·66*d.*
1902	43,203,584	4,743,178	47,946,762	£371,094	1·86*d.*
1901	38,119,086	4,149,087	42,268,173	£356,813	2·02*d.*
1900	39,475,254	4,366,457	43,841,711	£392,102	2·15*d.*
1899	40,512,104	4,682,270	45,194,374	£409,772	2·18*d.*
1898	40,143,837	4,732,573	44,876,410	£408,334	2·18*d.*
1897	40,658,303	4,678,055	46,336,358	£421,470	2·18*d.*

The train-mileage statement is set out beneath :

	December half, 1906.	December half, 1905.	Increase or decrease.	
Steam passenger train-miles	8,482	223,047	— 214,565	...
Electric passenger train-miles	1,171,013	808,056	+ 362,957	...
Total	1,179,495	1,031,103	+ 148,392	+ 14·3 per cent.
Freight train-miles	3,049	3,353	— 304	— 9·1 —
Total train-miles	1,182,544	1,034,456	+ 148,088	+ 14·3 per cent.
Earnings per passenger train-mile	40·92*d.*	43·63*d.*	— 2·71*d.*	— 6·2 per cent.
— per freight train-mile	182·76*d.*	174·79*d.*	+ 7·87*d.*	+ 4·5 —
— per total train-mile	41·29*d.*	44·06*d.*	— 2·77*d.*	— 6·2 —

[621 .33 (.45)]

5. — Italian railway electrification.

(*Railway Gazette.*)

During 1906, the Italian government has sanctioned the electrification of the following sections of the State railway system, at a total cost of 36,350,000 lire (about £1,450,000) :

Milan-Monza-Lecco	3,600,000 lire.
Usmate-Bergamo	1,400,000 —
Calolzio-Ponte S. Pietro	500,000 —
Gallarate-Laveno	2,600,000 —
Domodossola-Iselle	2,400,000 —
Naples-Salerno ter Torre Annunziata and Castellamare-Stabia	5,000,000 —
Genoa-Girdle-Line	800,000 —
Pontedecimo-Busalla	4,350,000 —
Pistoia-Porretta	8,000,000 —
Savona-San Giuseppe	3,500,000 —
Bardonecchia-Modane	4,200,000 —
Total.	36,350,000 lire.

[656 .28 (01]

6. — A railroad accident investigation bureau.

(*Railroad Gazette.*)

News of a killing railroad disaster comes by telephone and telegraph to five authorities — the railroad staff; the coroner; the district attorney; the State railroad commission; and the newspapers. While the railroad officers and men are caring for the hurt and dead, clearing the wreck, rebuilding the line, and searching for the cause, the four higher authorities are competing in independent investigations. The evidence is not collated, it is separated. The coroner arrests suspects, seizes broken parts and holds them as " exhibits, " halts the officers in charge of removals, and is apparently within the law in enforcing any order. The representatives of the district attorney and the commission are also lawfully entitled to get and keep, if they can, evidence for their own consideration. The newspaper men need no legal enactment for support in their work. They are not to be gainsaid. The result is a skirmish; it is often a scramble. The railroad officers' investigation is methodical, and judicial in form, but between those in charge of train movement, of track and of rolling stock, there is the human temptation to shift responsibility. They work in a storm of criticism, facing punishment, knowing that their findings will not be accepted by lurid critics who see them as criminals trying their own cases. It is disorderly. The railroad company investigations must always be made for railroad purposes, but the four other conflicting authorities are doing harm. An unassailable verdict is a judicial undertaking.

The establishment by congressional action of a bureau for investigating and making public the causes of important train accidents seems to be inevitable, and, if it is wisely planned and officered, should be not only inevitable but beneficent. To prevent erratic action there is needed a full knowledge of the working of similar departments in other countries, combined with the experience and judgment of railroad officers who have had to do with train handling, and also with the larger subject — the relation of the railroads to the public. The hasty introduction of such a bill as is under consideration by the Interstate Commerce Commission is the worst way and is illogical, although it is clearly within the province of the Commission to take the initiative. The subject may be well worth formal consideration by the American Railway Association, whose wonderful membership includes the ablest and best informed men in all departments of the art of transportation.

The British system is a basis for study. For more than sixty years it has worked successfully. There is a Railway & Canal Commission, which is concerned with maximum rates, and is in a limited way comparable with our Interstate Commerce Commission, but the Railway Department of the Board of Trade is the more active agent of government. In practical working, this Railway Department consists of a Secretary, who is in full charge of four inspectors, all of whom are army engineer officers; of two assistant inspectors, and two sub-inspectors. The Secretary's work consists largely of receiving, collating and reporting the statistical returns by the railroad companies and the inspectors' reports. An inspector's function is two-fold :

1° Before there can be opened for public use any new lines of railroad or material alteration or addition to an existing road or station or signalling installation or other safety device, an inspector passes on its adequacy and gives permission. It is theoretically possible to appeal from the decision of an inspector, but it is not done; his decision is accepted as final, unless upon further investigation he modifies or overrules it;

2° Accidents, resulting in loss of life or personal injury, and collisions or derailments involving a passenger train are referred to an inspector for investigation. In any serious case, the inspector receiving the assignment goes at once to the scene of the wreck, makes a careful examination of everything he can see, receives from the railroad officers all the information and the assistance that they can give him, summons every employee involved in the accident or who has seen any part of it, and then holds a formal inquiry, examining each witness in turn. After gathering all the information possible, he writes a report, which consists of Description, Evidence and Conclusion. The conclusion is apt to be followed by an appendix giving a list of damages done to road and rolling stock, and photographs, drawings, or other data for reference. The assistant inspectors investigate and report on minor accidents to railroad employees and other persons employed on railroad premises.

The important features of an inspector's report given in his conclusions consist of a clear statement of the cause of the accident and such recommendations as he not infrequently makes to the company for a change in its practice. In form, the company is not ordered, and indeed is not legally compelled to carry out the recommendation of the inspector; nevertheless, the relations of the inspector and the railroad officers are such that we know of no case of lasting disagreement, and this relation is due to two causes : The honesty of purpose and intelligence of a Board of Trade Inspectors is beyond question. He is always available for a conference to the end of preventing misunderstandings. Character and ability are absolute essentials for an autocrat, and an industrious officer with such attainments does his good work in the world more swiftly and with less friction than a commission.

An obvious criticism is the restriction of these inspectorships to those who are army enginere officers. It would seem at first sight that railroad officers who have had long experience in handling trains, in maintaining discipline among the employees, and almost daily means of judging the value of safety devices, would be the kind of men to be the most valuable inspectors. This is probably true, but there are difficulties involved in making such selection, and still further difficulties involved in coaxing away from railroad service men of sufficient experience combined with the judicial faculty. Moreover, by so much as the field of selection is enlarged, there is an increase in the chances to appoint men for reasons other than fitness. The personal of the thirty-five State railroad commissions in this country, and perhaps in this we may also include the Interstate Commerce Commission, does not indicate that a wide range of possible selection is the wisest method of securing the best qualified officers.

From the nature of his work, the inspector has much leisure time. He has periods of intense application to difficult problems; he does not always succeed in finding the cause of the accident; his term of service is for life, or to an age of retirement; he therefore has every incentive to study his business as a science; to learn railroad methods thoroughly; and he has also the time for this work. The writer has never found a British railway officer, who considered the inspector's investigations, decisions and recommendations to be other than a help to him; and this, too, in spite of the fact that the inspector makes mistakes. He may make an error in his finding that a locomotive which has left the track was of a type not safe for the speed at which the company has been accustomed to run it. The company officers may, on the other hand, believe that the derailment was due to a defect in the permanent way. This does not lead the conservative inspector to make hasty judgment limiting the speed of such locomotives, although his report may be suggestive of such a limitation. No friction between the company and the department results, for the company has ample opportunity to demonstrate in practice whether or not the type is dangerous, and the inspector is quite as ready to accept the officer's evidence as the officer is to accept recommendations.

We venture the opinion that no American railroad officer, experienced in facing coroner's and other investigations, who will avail himself of the opportunity to attend a Board of Trade Inspector's Inquiry, will fail to be impressed by the advantages of the public investigation by an entirely independent trained judge. In our method, the railroad officer surely wants to find the truth, and his advantage is that he already has a lot of stored information concerning the defects and merits of his track, structures, equipment and men; but information does not imply the capacity to weigh contradictory evidence. A United States District Court Judge, in hearing and deciding a patent infringement suit, with no engineering education or practical experience in mechanics, finds his way through the mazes of the triple valve, interlocking device, track circuit, pneumatic tool and the like — finds the truth and makes it a public record. This public record of the facts obtained by an independent official investigation of the causes of serious accidents, is sure to be of great value to the railroads in their relations to government and to the people.

An act dealing with this subject will become a law, and when it is enforced it may be either a benefit or a hindrance. It is for the railroad officers to decide whether they will either take the initiative in submitting a plan; or in some proper way make their knowledge and results of experience available; or wait for the probably costly results of a law framed by less well informed persons.

[385 .581 (.73)]

7. — Act limiting hours of service of railway employes in the United States.

(*Railway Age.*)

Following are the provisions of the act " to promote the safety of employes and travellers upon railroads by limiting the hours of service of employes thereon," which was passed by congress at the session just closed, and signed by President Roosevelt on March 4 :

Section 1. — That the provisions of this act shall apply to any common carrier or carriers, their officers, agents and employes, engaged in the transportation of passengers or property by railroad in the District of Columbia or any territory of the United States, or from one state or territory of the United States or the District of Columbia to any other state or territory of the United States or the District of Columbia, or from any place in the United States to an adjacent foreign country, or from any place in the United States through a foreign country to any other place in the United States. The term " railroad " as used in this act, shall include all bridges and ferries used or operated in connection with any railroad, and also all the road in use by any common carrier operating a railroad, whether owned or operated under a contract, agreement or lease; and the term " employes " as used in this act shall be held to mean persons actually engaged in or connected with the movement of any train.

Section 2. — That it shall be unlawful for any common carrier, its officers or agents, subject to this act, to require or knowingly permit any employe subject to this act to be or remain on duty for a longer period than 16 consecutive hours, and whenever any such employe of such common carrier shall have been continuously on duty for 16 hours, he shall be relieved and not required or permitted again to go on duty until he has had at least 10 consecutive hours off duty; and no such employe who has been on duty 16 hours in the aggregate in any 24-hour period, shall be required or permitted to continue or again go on duty without having had at least eight consecutive hours off duty; unless immediately prior to said 24-hour period, such employe had at least 8 consecutive hours off duty, and during said period of 24 hours following, had at least 6 consecutive hours off duty : Provided, That no operator, train dispatcher or other employe, who by the use of the telegraph or telephone dispatches reports, transmits, receives or delivers orders pertaining to or affecting train movements, shall be required or permitted to be or remain on duty for a longer period than 9 hours in any 24-hour period in all towers, offices, places and stations continuously operated night and day, nor for a longer period than 13 hours in all towers, offices, places and stations operated only during the daytime, except in case of emergency, when the employes named in this proviso may be permitted to be and remain on duty for four additional hours in a 24-hour period on not exceeding three days in any week : Provided further, That the Interstate Commerce Commission may, after full hearing in a particular case and for good cause shown, extend the period within which a common carrier shall comply with the provisions of this proviso as to said case.

Section 3. — That any such common carrier, or any officer or agent thereof, requiring or knowingly permitting any employe to go, be or remain on duty in violation of the second section hereof, shall be liable to a penalty of not to exceed $500 for each and every violation to be recovered in a suit or suits to be brought by the United States district attorney in the district court of the United States having jurisdiction in the locality where such violation shall have been committed; and it shall be the duty of such district attorney, under direction of the attorney-general, to bring such suits upon information being lodged with him; but no such suit shall be brought after the expiration of one year from the date of such violation; and it shall also be the duty of the Insterstate Commerce Commission to lodge with the proper district attorneys information of any such violations as may come to its knowledge. In all prosecutions under this act, the common carrier shall be deemed to have had knowledge of all acts of its officers and agents : Provided, That the provisions of this act shall not apply in any case of casualty or unavoidable accident or the act of God; nor where the delay was the result of a cause not known to the carrier, its officer or agent in charge of such employe at the time said employe left a terminal, and which could not have been foreseen : Provided further, That the provisions of this act shall not apply to the crews of wrecking or relief trains.

Section 4. — It shall be the duty of the Interstate Commerce Commission to execute and enforce the provisions of this act, and all powers granted to the Interstate Commerce Commission are hereby extended to it in the execution of this act.

Section 5. — That this act shall take effect and be in force one year after its passage.

NEW BOOKS AND PUBLICATIONS

[**621 .13** (02 & **385.** (04]

GAIRNS (J. F.). — **Locomotive compounding and superheating.** A practical text-book for the use of railway and locomotive engineers, students and draughtsmen. — 1 volume in-octavo ($8\,{}^{11}/_{16} \times 5\,{}^{1}/_{2}$ inches), XXI + 189 pages with 148 illustrations in the text. — 1907, London, Charles Griffin & C°, Limited, Exeter Street, Strand. Price : bound, 8*s.* 6*d.*

Many engineers, and among them most French experts, regard as quite decisive the advantages offered by compound locomotives. Another school thinks that the disadvantages of periodic condensations are more successfully overcome by superheated steam, the use of which involves possibly less complication than double expansion.

It is therefore round compounding and superheating that is concentrated the main interest of building a modern locomotive and, judging by the strong arguments invoked on the two sides, we may gather that the question is not yet settled. Will further experiments enable us to propound any decisive and general conclusion? This seems open to doubt, for the complexity of the problem and the variety in the conditions of operation will always leave a fair opening for the individual preferences of railway engineers.

Be this as it may, everything appertaining to double expansion and superheating possesses the highest interest at the present time, and we must be grateful to Mr. Gairns for having collected in a clear and concise shape everything of importance on the subject, much of which is scattered in the various technical journals.

The classification, the reasons for which are explained in chapter III, is simple and reasonable and it makes reference very easy.

Chapter IV is devoted to the history and growth of the compound locomotive.

In chapter V and its successors, the author examines the various types of double expansion locomotives : two cylinders non-automatic and automatic, three cylinders, four cylinders and two cranks (tandem and non-tandem), four cylinders with pistons acting on the same axle (balanced systems), as in the Gölsdorf locomotive, and four cylinders with pistons acting on two different axles (balanced and divided systems), represented especially by the well known de Glehn type, used on most of the French lines.

The last chapter is the only one occupied with the consideration of superheated steam. The importance of the subject would perhaps have justified a little more space, but superheating is of fairly recent date and this fact, considering all things, restricts what there is of general interest within a comparatively small scope.

The author places in front of his book a glossary giving the meaning of all the special terms, a valuable addition for the sake of clearness which will prove of great assistance especially to all those who do not claim English as their mother tongue.

A. H.

[**621** .13 & 385. (04]

HERDNER (A.), engineer in chief, assistant to the chief mechanical engineer of the French Midi Railway. — **Les locomotives à l'Exposition de Liége** (1905) (**The locomotives at the Liége Exhibition**). — 1 volume in-octavo (27 × 18 1/2 centimetres [10 5/8 × 7 5/16 inches]), 186 pages with 173 illustrations in the text. — 1906, Paris, Chaix printing press, 20, rue Bergère.

The work, a fine volume consisting of 186 pages, includes extracts from the reports of the *Société des ingénieurs civils de France* (*Bulletin* of September 1906) and deserves special mention, because, despite its too modest title, it is a real treatise upon the modern locomotive.

The book is subdivided into three portions : the vehicle, the production of steam and the utilisation of the steam, and under these three headings the author treats in masterly fashion all the remarkable peculiarities in construction of the modern locomotive, all the desiderata which rouse the ingenuity of engineers, all the vast questions which dominate the understanding and planning of an engine. And this account possesses none of the dryness of an ordinary account of an exhibition; it is carried out with a breadth of view, method and clearness that give it no inconsiderable instructive value.

Much might be quoted from this splendid work. We prefer, however, to refer the reader, who can appreciate things well thought out and well expressed, to the book itself and we shall content ourselves with alluding more especially to the excellent study upon compounding and superheating round which gravitates the construction of the modern locomotive.

A. H.

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Secretary General of the Permanent Commission of the International Railway Congress

[016 .385. (02]

I. — BIBLIOGRAPHY OF BOOKS

(May, 1907.)

In French.

1906 **621** .1

MINISTÈRE DU COMMERCE DE FRANCE.

Rapports du jury international de l'exposition universelle internationale de 1900, à Paris. Classe 19 : **Machines à vapeur.** Rapport de M. Charles Walckenaer, ingénieur en chef des mines.

Paris, imprimerie Nationale. In-8°, 692 pages et figures.

1907 **388** (.44)

MOSSÉ (A.), docteur en droit.

Les transports en commun à Paris.

Paris, Rivière, éditeur. 1 volume in-8°, 415 pages. (Prix : 8 francs.)

1906 **385** .581 (.44)

OFFICE DU TRAVAIL DE PARIS.

Notes sur la journée de huit heures dans les établissements industriels de l'État.

Paris, imprimerie Nationale. (230 × 155), 94 pages.

1907 **62.** (02

PETIT (J.-E.), conducteur principal des ponts et chaussées.

Aide-mémoire des conducteurs et commis des ponts et chaussées, agents voyers, chefs de section, conducteurs et piqueurs des chemins de fer, contrôleurs, etc.

Paris, Béranger, éditeur. Deuxième édition, 1 volume, 368 figures dans le texte. (Prix : 15 francs.)

1907 **621** .33 & **625** .4

THIERRY (J. B.), conducteur des ponts et chaussées.

Étude sur le Métropolitain de Paris. Ses installations intérieures. Ce qu'elles sont. Ce qu'elles devraient être.

Paris, librairie Béranger. 1 volume in-8°, 18 figures et 4 planches hors texte. (Prix : 7.50 francs.)

In German.

1906 **656** .212.6

BESSEL (C.).

Eine Sammlung von Zeichnungen ausgeführter Konstruktionen mit besonderer Berücksichtigung der Hebemaschinen-Elemente.

Berlin, Julius Springer. 34 Tafeln. (Preis : 6 Mark.)

1906 **625** .13

PRESSEL (Dr. R.), Professor an der technischen Hochschule in München.

Die Bauarbeiten am Simplon-Tunnel. (Sonderabdruck aus der *Schweizerischen Bauzeitung*.)

Zürich. (Preis : 2 Mark.)

1907 **313** .385 (.43)

REICHS-EISENBAHN-AMT.

Statistik der im Betriebe befindlichen Eisenbahnen Deutschlands nach den Angaben der Eisenbahn-Verwaltgn. XXVI. Band. Rechnungsjahr 1905.

Berlin, E. S. Mittler & Sohn. (395 × 300), 1 farb. Karte (Preis : 10 Mark.)

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[1] The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels. (See "Bibliographical Decimal Classification as applied to Railway Science," by L. Weissenbruch, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

N. B. — The Monthly Bibliography is printed on one side only so that it may be cut up into slips and pasted on labels for catalogues and indexes.

1907 **625** .1 (02

SCHÖLER (R.), Bausch.-Dir.

Handbuch des Bauingenieurs. Eine vollständ. Sammlung der an den Tiefbauschulen gelehrten techn. Unterrichtsfächer. Zum Gebrauche für die Schule und Praxis. Band IV : **Der Eisenbahnbau** von STROHMEYER (K.), Ingen. Baugewerksch.-Oberlehr.

Leipzig, B. F. Voigt. In-8°, XII-208 Seiten mit 312 Textabbildungen und 8 Tafeln. (Preis : 6 Mark.)

1907 **656** .257. (02

SCHUBERT (E.), geh. Baur.

Katechismus für den Weichensteller-Dienst. Ein lehr- und Nachschlagebuch für Stellwerkswärter, Weichensteller, Hilfsweichensteller und Rottenführer. Nach den neuesten Vorschriften ergänzt durch Reg.- und Baur. R. v. ZABIENSKY.

Wiesbaden, J. F. Bergmann. 15. Aufl., in-8°, VIII-181 Seiten, 104 Abbildungen. (Preis : 1.60 Mark.)

1907 **621** .137.1 (02

WINKLER (R.).

Die Heizerschule. Hülfsbuch für Maschinisten und Dampfkesselheizer.

Berlin, Selbstverlag. 3. Auflage, 123 Seiten mit 142 Figuren und 8 Tafeln. (Preis : 1.50 Mark.)

In English.

1907 **624**. (06

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.

Proceedings of the sixteenth annual convention, held at Boston, Mass. October 16, 17 and 18, 1906.

Concord., N. H. 300 pages (9 × 6 inches).

1907 **62**. (02

BRANCH (Joseph Gerald).

Stationary engineering : a reference and text book written expressly for stationary engineers and firemen, also mechanical engineers, consulting engineers, electrical engineers, universities and schools.

St. Louis, National Equipment Co. 8vo, 940 + 51 pages, tables, diagrs., 300 illustrations. (Price : $3.50.)

1907 **669** .1

CAMPBELL (Harry Huse), Metallurgical Engineer.

The manufacture and properties of iron and steel.

New York and London, Hill Publishing Co. Fourth edition, XXVI + 639 pages (9 1/4 × 6 inches), numerous text illustrations and tables. (Price : $5.)

1907 **625** .253. (02

CONGER (Clinton Barker).

The air brake catechism and instruction book on the construction and operation of the Westinghouse air brake and the New York air brake, with a list of examination questions for enginemen and trainmen.

Grand Rapids, Mich., A. F. Conger. 16mo, 227 + 4 pages, front. diagrams. (Price : $1.)

1907 **625** .13

COPPERTHWAITE (W. C.).

Tunnel shields and the use of compressed air in subaqueous works.

New York, D. Van Nostrand Co. 4to, 389 pages, il. (Price : $9.)

1907 **625** .253. (02

DUKESMITH (Frank Hutchinson).

Modern air brake practice, its use and abuse : a book of instruction on the automatic high speed and straight air brake, together with questions and answers, for enginemen, trainmen and motormen.

Chicago, Frederick J. Drake & Co. 8vo, 437 pages, fold. pls. diagrams. (Price : $1.50.)

1907 **621** .2 (01

FRENCH (Lester G.), S. B., Mechanical Engineer.

Steam turbines. Practice and theory.

Brattleboro, Vt., the Technical press. 418 pages (9×5 1/2 inches), numerous text illustrations and tables. (Price : $3.)

1907 **385** .1 (02

Hand-book of railroad securities.

New York, William B. Dana Co. 192 pages (8 1/2 × 4 1/2 inches). (Price : $1.)

1906 **621** .116

HAYS (Joseph W.).

Combustion and smokeless furnaces.

New York, Hill Publishing Co. 104 pages (9 1/8 × 5 1/4 inches). (Price : $1.50.)

1907 313 : **656** .28 (.42)

Railway. Accidents. Returns and inspectors' reports for July to September 1906.

London, P. S. King & Son. Plans. (Price : 3*s*. 3*d*.)

1907 **385**. (02

SEKON (G. A.).

The railway year book for 1907.

London, *The Railway Magazine*. 342 pages (8 3/4 × 6 × 1 inches.) (Price : 2*s*. 6*d*.)

1907 **313** .385

Twenty years' railway statistics, 1887 to 1907.

London, F. C. Mathieson & Sons. 250 pages (6 1/2 × 3 1/2 × 1/2 inches). (Price : 1*s*.)

In Italian.

1907 **625** .216. (06.4

MONTU (Carlo), Ing. prof.

Gli accoppiatori automatici per veicoli ferroviari all' Esposizione di Milano.

Torino-Roma, Società tipografico-editrice nazionale. In-8°, 48 pagine.

II. — BIBLIOGRAPHY OF PERIODICALS

(April, 1907.)

In French.

Bulletin de l'Association du Congrès international des chemins de fer.

(Bruxelles.)

1907 **656** .253

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 357.

WEISSENBRUCH (L.). — Note sur les sémaphores universels transformables des chemins de fer de l'État belge. (7,700 mots & fig.)

1907 **625** .216

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 397.

HUBERTI (A.) & DOYEN (J.). — Les appareils à friction dans les attelages des véhicules de chemins de fer. (2,700 mots & fig.)

1907 **621** .133.2

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 405.

RAGNO (S.). — La réparation des plaques tubulaires des foyers des chaudières de locomotives. (7,600 mots & fig.)

1907 **656** .237.2

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 425.

HERVIEU (J.). — Appareil imprimeur-distributeur-contrôleur de billets de chemins de fer. (5,300 mots & fig.)

1907 **621** .133.5

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 439.

Les essais de l' « American Engineer » sur les appareils de tirage des locomotives. (3,900 mots & fig.)

1907 **656** .254

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 447.

La télégraphie sans fil dans le service des chemins de fer. (500 mots.)

1907 **385** .15 (.45)

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 448.

Notes sur les chemins de fer de l'État italien. (2,300 mots.)

1907 **656** .256

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 451.

Signaux de block-system sur les chemins de fer américains. (350 mots & 1 tableau.)

1907 **621** .134.3

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 456.

La simple expansion et la réduction des pressions. (1,100 mots.)

1907 **625** .254

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 458.

Anomalies dans le fonctionnement du frein à vide. (900 mots.)

1907 **725** .31

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 461.

Projet de bâtiment à usage de station et bureaux à ériger au terminus du tunnel de la rivière Hudson. (700 mots & fig.)

1907 **621** .13 (02 & **385**. (04

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 463.

Compte rendu bibliographique : Locomotive compounding and superheating (Le compoundage et la surchauffe dans les locomotives), par J. F. Gairns. (450 mots.)

1907 **016** .385. (02

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 45.

Bibliographie mensuelle des chemins de fer. — Livres. (29 fiches.)

1907 **016** .385. (05

Bulletin du Congrès des chemins de fer, nº 4, avril, p. 48.

Bibliographie mensuelle des chemins de fer. — Périodiques. (176 fiches.)

Bulletin de l'Institut international de bibliographie.

(Bruxelles.)

1907 **01** (06.2

Bulletin de l'Institut internat. de bibliographie, fasc. 1-3, p. 3.

La documentation. (2,600 mots & fig.)

Bulletin de la Société d'encouragement pour l'industrie nationale.

(Paris.)

1907 **621** .97

Bulletin de la Soc. d'encour. pour l'ind. nat., nº 2, mars, p. 234.

SAUVAGE (E.). — Rapport fait, au nom du comité des arts mécaniques, sur un mécanisme de commande des appareils à choc, présenté par M. Luc Denis. (1,900 mots & fig.)

Bulletin de la Société des ingénieurs civils de France. (Paris.)

1907 624 .2 (01

Bulletin de la Soc. des ingén. civils de France, février, p. 257.

CHAUDY (F.). — Essai d'une théorie de la flexion des poutres droites en béton armé. (5,300 mots & fig.)

1907 62. (01 (06.3

Bulletin de la Soc. des ingén. civils de France, février, p. 298.

GUILLET (L.). — Compte rendu du congrès des méthodes d'essais des matériaux de construction, Bruxelles 1906. (13,000 mots, 1 tableau & fig.)

1907 721 .9 (.460)

Bulletin de la Soc. des ingén. civils de France, mars, p. 422.

RIBERA (J.-E.). — Le béton armé en Espagne. 3,800 mots & fig.)

1907 621 .134.3

Bulletin de la Soc. des ingén. civils de France, mars, p. 487.

Locomotives à vapeur surchauffée. (1,300 mots.)

Bulletin des transports internationaux par chemins de fer. (Berne.)

1907 313 .385 (.43)

Bulletin des transports intern. par chemins de fer, avril, p. 160.

Statistique des chemins de fer exploités en Allemagne pendant l'exercice 1905. (250 mots & 1 tableau.)

Génie civil. (Paris.)

1907 656 .212.6

Génie civil, nº 1296, 13 avril, p. 401.

HOFER (F.). — Grue hydraulique de 150 tonnes. ,600 mots & fig.)

1907 625 .142.3 & 691

énie civil, nº 1296, 13 avril, p. 403.

LEMAIRE (E.). — La conservation des bois par les ouvelles méthodes d'imprégnation. (5,700 mots.)

1907 625 .151

énie civil, nº 1297, 20 avril, p. 428.

Aiguille de sûreté, système Schilban. (900 mots & fig.)

1907 621 .14

énie civil, nº 1298, 27 avril, p. 441.

BIDAULT DES CHAUMES (A.). — Train automobile e la Société Freibahn pour le transport des marchandises. ,100 mots & fig.)

1907 625 .142.2

énie civil, nº 1298, 27 avril, p. 444.

La conservation des traverses de chemins de fer. énétration de la chaleur dans le bois. (2,500 mots & tableau.)

Journal des transports. (Paris.)

1907 656 .235.7

Journal des transports, nº 15, 13 avril, p. 174.

Les transports agricoles. (1,000 mots.)

1907 656 .24 (.42 + .43)

Journal des transports, nº 16, 20 avril, p. 182.

Réseaux anglais et allemands. (1,000 mots.)

Nouvelles annales de la construction. (Paris.)

1907 721 .9

Nouvelles annales de la construction, nº 628, avril, p. 57.

Emploi du béton armé. — Circulaire ministérielle du 20 octobre 1906. (4,800 mots & fig.)

Revue économique internationale. (Bruxelles.)

1907 385 .1 (.47)

Revue économique internationale, nº 1, avril, p. 108.

LAUWICK (M.). — Le futur régime des chemins de fer en Russie. (8,000 mots & 1 carte.)

1907 656 .27

Revue économique internationale, nº 1, avril, p. 194.

BELLET (D.). — Chronique des transports. (4,700 mots.)

Revue générale des chemins de fer et des tramways. (Paris.)

1907 624 .2 (01

Revue générale des chemins de fer, nº 4, avril, p. 179.

HAUSSER & CUNQ. — Calcul des fermes de charpente. Cas particuliers des poutres à travées solidaires. (3,500 mots & fig.)

1907 621 .132.5

Revue générale des chemins de fer, nº 4, avril, p. 194.

JAPIOT (M.). — Note sur l'emploi de locomotives articulées de grande puissance aux États-Unis. (6,500 mots & fig.)

1907 313 .385 (.54)

Revue générale des chemins de fer, nº 4, avril, p. 209.

Les chemins de fer de l'Inde anglaise pendant l'année 1904. (10 tableaux.)

1907 656 .234 (.45)

Revue générale des chemins de fer, nº 4, avril, p. 216.

Le nouveau tarif-voyageurs des chemins de fer de l'État italien. (1,600 mots & 2 tableaux.)

1907 385 .113 (.493)

Revue générale des chemins de fer, nº 4, avril, p. 221.

Le compte rendu des chemins de fer belges pour l'année 1905. (1,700 mots & 3 tableaux.)

907 **656** .257
vue générale des chemins de fer, nº 4, avril, p. 225.

Nouveau dispositif pour la manœuvre électrique des naux et des aiguilles en service à la gare de Courcelles-nture à Paris. (1,200 mots & fig.)

907 **656** .253
ue générale des chemins de fer, nº 4, avril, p. 229.

Exposition de Milan. Appareils exposés par les chemins fer de l'État italien. (900 mots.)

907 **621** .131.3
ue générale des chemins de fer, nº 4, avril, p. 230.

ssais de locomotives à vapeur surchauffée. (1,000 mots 0 tableaux.)

Revue de l'ingénieur et index technique. (Bruxelles.)

)07 **621** .7
ue de l'ingénieur et index technique, nº 1, avril, p. 1.

administration d'une industrie. (3,000 mots, 2 taux & fig.)

Revue politique et parlementaire. (Paris.)

07 **625** .1 (.44 + .45)
e politique et parlementaire, nº 154, avril, p. 48.

DISEAU (C.). — Du Simplon au Mont-blanc. 00 mots & fig.)

In German.

nalen für Gewerbe und Bauwesen. (Berlin.)

07 **656** .215
len für Gewerbe und Bauwesen, Nr 715, 1. April, S. 129.

RCHART. — Elektrische Beleuchtungs- und übertragungsanlage auf Bahnhof Neuss. (1 100 ter & Abb.)

07 **621** .14
len für Gewerbe und Bauwesen, Nr 716, 15. April, S. 150.

eibahnzug. (1 000 Wörter & Abb.)

Beton und Eisen. (Berlin.)

07 **624** .63
und Eisen, Heft IV, S. 92.

WAK (A.). — Der Eisenbetonbau bei den neuen, h die k. k. Eisenbahnbaudirektion hergestellten linien der österreichischen Monarchie. (400 Wörter b.)

Bulletin des internationalen Eisenbahn-Kongress-Verbandes. (Brüssel.)

1907 **656** .223.2
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 317.

ALLEN (W. F.). — Gegenseitige Benutzung von Güterwagen auf nordamerikanischen Eisenbahnen. (4 800 Wörter.)

1907 **621** .131.3
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 329.

GOSS (W. F. M.). — Lokomotiv-Prüfungen. (9 900 Wörter, Tabellen & Abb.)

1907 **621** .138.3
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 371.

ROESCH (F. P.). — Die Wartung der Lokomotivkessel auf der Endstation und während der Fahrt. (2 800 Wörter.)

1907 **621** .33
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 377.

WYSSLING (W.). — Mitteilungen der schweizerischen Studienkommission für elektrischen Bahnbetrieb. (6 700 Wörter & Tabellen.)

1907 **625** .61 (09.1 (.54)
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 395.

Die Barsi-Kleinbahn. (3 100 Wörter & Abb.)

1907 **625** .143.2
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 403.

JOB (Robert). — Stahlschienen: ihre Zusammensetzung und ihr Querschnitt. (1 700 Wörter.)

1907 **313 : 625** .14
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 406.

Die Benutzung von Querschwellen auf den Eisenbahnen in den Vereinigten Staaten im Jahre 1905. (600 Wörter & 3 Tabellen.)

1907 **625** .254
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 410.

Unzuverlässige Wirkung der Vakuum Bremse. (850 Wörter.)

1907 **656** .234 (.45)
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 412.

Eine Reform der italienischen Personen tarife. (1 100 Wörter & 5 Tabellen.)

1907 **385**. (09.2
Bulletin des Eisenbahn-Kongresses, Nr 4, April, S. 419.

Nachruf: Alexander Johnston CASSATT. (1 800 Wörter & Bildniss.

907 **016** .385. (02
letin des Eisenbahn-Kongresses, Nr 4, April, S. 45.

Ionatliches Verzeichnis der Eisenbahnliteratur. — her. (29 Zettel.)

907 **016** .385. (05
etin des Eisenbahn-Kongresses, Nr 4, April, S. 48.

Ionatliches Verzeichnis der Eisenbahnliteratur. — schriften. (176 Zettel.)

Elektrische Bahnen und Betriebe.
tschrift für Verkehrs- und Transportwesen.
(München.)

07 **621** .33
trische Bahnen u. Betriebe, Heft 10, 4. April, S. 181.

CHAUER. — Die staatliche elektrische Güterbahn euben. (1 500 Wörter & Abb.)

07 **621** .33
trische Bahnen u. Betriebe, Heft 11, 13. April, S. 201.

EICHEL (W.). — Ueber die Einführung des elekhen Zugbetriebes auf den Berliner Stadt-, Ring- und rtbahnen. (4 500 Wörter, 3 Tabellen & Abb.)

07 **621** .33 & **625** .3
trische Bahnen u. Betriebe, Heft 11, 13. April, S. 209.

ERZOG (S.). — Die Arth-Rigibahn. (1 100 Wörter bb.)

gan für die Fortschritte des Eisenbahnvesens in technischer Beziehung. (Wiesbaden.)

07 **621** .13 (06.4
n für die Fortschritte des Eisenbahnw., 3. Heft, S. 47.

EBELACKER (H.). — Uebersicht der in Mailand ausgestellten Lokomotiven. (8 500 Wörter & Abb.)

07 **725** .33
n für die Fortschritte des Eisenbahnw., 3. Heft, S. 58.

USSE (O.). — Verbesserung an Wasserkranen. (250 ter & Abb.)

07 **621** .132.3
n für die Fortschritte des Eisenbahnw., 4. Heft, S. 67.

NZIN (R.). — Vergleich zwischen einer zwei- und r dreifach gekuppelten Schnellzug-Lokomotive. 0 Wörter, Tabellen & Abb.)

07 **385.** (01 (.67) & **625** .611 (.67)
n für die Fortschritte des Eisenbahnw., 4. Heft, S. 75.

ECHSLER (M.). — Die Otavi-Bahn. (1 000 Wörter b.)

07 **625** .26
n für die Fortschritte des Eisenbahnw., 4. Heft, S. 76.

MMERMANN. — Werkstätte zur Untersuchung der en in der Hauptwerkstätte Karlsruhe. (550 Wörter b.)

1907 **656** .221
Organ für die Fortschritte des Eisenbahnw., 4. Heft, S. 78.

MÜHLMANN. — Das Anfahren der Eisenbahnzüge. (800 Wörter, 1 Tabelle & Abb.)

1907 **625** .11 (.494 + .45)
Organ für die Fortschritte des Eisenbahnw., 4. Heft, S. 81.

Die Splügenbahn. (600 Wörter & Abb.)

1907 **656** .281
Organ für die Fortschritte des Eisenbahnw., 4. Heft, S. 86.

Die Entgleisung von Salisbury. (1 700 Wörter & Abb.) (S. *Bulletin du Congrès des chemins de fer*, Nr 8 und 11, August und November 1906.)

Schweizerische Bauzeitung. (Zürich.)

1907 **62.** (01 & **624** .2 (01
Schweizerische Bauzeitung, Nr 16, 20. April, S. 198.

Versuche über die Schubwirkungen bei Eisenbetonträgern. (1 800 Wörter, 1 Tabelle & Abb.)

Zeitschrift für Kleinbahnen. (Berlin.)

1907 **313** : **625** .61 (.43)
Zeitschrift für Kleinbahnen, Heft 4, April, S. 233.

Statistik der Kleinbahnen im Deutschen Reiche für das Jahr 1905. (5 000 Wörter & Tabellen.)

Zeitschrift des österreichischen Ingenieur- und Architekten-Vereines. (Wien.)

1907 **621** .13 (06.4
Zeit. des öst. Ingen.- und Archit.-Ver., Nr 14, 5. April, S. 249.

SANZIN (R.). — Die Lokomotiven auf der Internationalen Ausstellung in Mailand 1906. (2 400 Wörter, 1 Tabelle & Abb.)

Zeitschrift des Vereines deutscher Ingenieure. (Berlin.)

1907 **656** .211 (.73)
Zeit. des Vereines deutscher Ingen., Nr 15, 13. April, S. 573.

GIESE (E.) & BLUM. — Personen- und Abstellbahnhöfe Nordamerikas. (3 600 Wörter & Abb.)

1907 625 .616
Zeitsch. des Vereines deutscher Ingen., Nr 17, 27. April, S. 665.

DOEPPNER (A.). — Die Baulokomotiven. (1 600 Wörter, 3 Tabellen & Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1907 625 .13
Zeitung des Vereins, Nr 26, 6. April, S. 407.

BERDROW (W.). — Die Arbeiten an der Berliner Untergrundbahn. (3 500 Wörter.)

1907 385 .1 (.42)
Zeitung des Vereins, Nr 28, 13. April, S. 443.
— Nr 29, 17. — S. 459.

V. DER LEYEN (A.). — Neuere Schriften zur englischen Eisenbahntarifpolitik. (4 500 Wörter)

1907 656 .237
Zeitung des Vereins, Nr 30, 20. April, S. 475.

NITZSCHKE (W. H.). — Vorschläge zur Vereinfachung der Abrechnungslegung im Güterverkehr. (1 400 Wörter & 3 Tabellen.)

1907 385 .13
Zeitung des Vereins, Nr 31, 24. April, S. 491.

HERBST. — Besteuerung des Eisenbahnfiskus. (1 600 Wörter.)

1907 621 .33 (.42)
Zeitung des Vereins, Nr 32, 27. April, S. 507.

Stand der elektrischen Einrichtungen auf den englischen Eisenbahnen. (700 Wörter & 5 Tabellen.)

Zentralblatt der Bauverwaltung. (Berlin.)

1907 656 .211
Zentralblatt der Bauverwaltung, Nr 35, 27. April, S. 237.

Die Umgestaltung der Bahnanlagen bei Stuttgart. (1 000 Wörter & Abb.)

In English.

American Engineer and Railroad Journal. (New York)

1907 621 .132.5
American Engineer & R. Journal, April, p. 133.

Simple Decapod locomotive. (600 words, 1 table & fig.)

1907 621 .132.8 (.42)
American Engineer & R. Journal, April, p. 134.

LAKE (C. S.). — Recent steam motor cars in Great Britain. (900 words & fig.)

Bulletin of the American Railway Engineering and Maintenance of Way Association. (Chicago.)

1907 625 .15
Bull. Amer. Ry. Eng. & Maint. of Way Ass., No. 85, March, p. 11.

Standard specifications for mechanical interlocking and material for construction work. (3,500 words, 1 table & fig.)

1907 625 .151
Bull. Amer. Ry. Eng. & Maint. of Way Ass., No. 85, March, p. 39.

Report of Committee, No. V. — On track. (1,000 words & fig.)

1907 625 .142.2 & 691
Bull. Amer. Ry. Eng. & Maint. of Way Ass., No. 85, March, p. 53.

HATT (W. K.). — Results of recent work of the timber tests by the forest service, United States Department of Agriculture. (2,800 words, 7 tables & fig.)

1907 625 .142.2
Bull. Amer. Ry. Eng. & Maint. of Way Ass., No. 85, March, p. 75.

Report of Committee, No. III. — On ties. (8,400 words.)

Bulletin of the International Railway Congress Association. (Brussels.)

1907 625 .14 (01
Bulletin of the Railway Congress, No. 4, April, p. 379.

SCHLÜSSEL (L.). — Note on the economic renewal and maintenance of railway tracks for high speed traffic. (12,700 words, 1 table & fig.)

1907 621 .132.7 & 621 .335
Bulletin of the Railway Congress, No. 4, April, p. 414.

UYTBORCK (Em.). — Petrol-electric (mixed traction) locomotive on the Belgian State Railways for shunting goods wagons. (3,000 words & fig.)

1907 625 .143.3
Bulletin of the Railway Congress, No. 4, April, p. 423.

LUBIMOFF (Léon DE). — Note on the wear of rails. (3,800 words, 5 tables & fig.)

1907 621 .134.3
Bulletin of the Railway Congress, No. 4, April, p. 438.

GOSS (W. F. M.). — High steam pressure in locomotive service. (3,200 words & fig.)

1907 625 .253
Bulletin of the Railway Congress, No. 4, April, p. 445.

The Chapsal-Saillot compressed-air brake. (1,600 words & fig.)

1907 625 .61 (09.1 (.54)
Bulletin of the Railway Congress, No. 4, April, p. 450.

The Barsi Light Railway. (2,800 words & fig.)

1907 385 .21
Bulletin of the Railway Congress, No. 4, April, p. 457.

COLSON (C.). — Internal navigation in 1905. (Review of traffic questions.) (5,000 words & 1 table.)

1907 725 .31
Bulletin of the Railway Congress, No. 4, April, p. 466.

Proposed down-town terminal of the Hudson River tunnel system. (700 words & fig.)

1907 656 .234 (.45)
Bulletin of the Railway Congress, No. 4, April, p. 469.

The reform in the Italian passenger tariff. (1,400 words & 5 tables.)

1907 **656** .256
Bulletin of the Railway Congress, No. 4, April, p. 473.

Block signals on American railroads. (300 words & 1 table.)

1907 **656** .222.1
Bulletin of the Railway Congress, No. 4, April, p. 476.

The dangers of speed. (1,450 words.)

1907 **016** .385. (02
Bulletin of the Railway Congress, No. 4, April, p. 45.

Monthly bibliography of railways. — Books. (29 labels.)

1907 **016** .385. (05
Bulletin of the Railway Congress, No. 4, April, p. 48.

Monthly bibliography of railways. — Periodicals. (176 labels.)

Engineer. (London.)

1907 **621** .14
Engineer, No. 2675, April 5, p. 351.

BEAUMONT (W. W.). — Petrol motor omnibuses. (2,700 words & fig.)

1907 **621** .132.3
Engineer, No. 2676, April 12, p. 371.

Six-coupled locomotives. (900 words).

1907 **621** .33 (.45).
Engineer, No. 2677, April 19, p. 388.

Electrical traction in Italy. (700 words & fig.)

1907 **621** .132.3
Engineer, No. 2677, April 19, p. 390.

Italian balanced compound locomotive. (1,100 words, 1 table & fig.)

1907 **313** .385 (.54)
Engineer, No. 2678, April 26, p. 420.

The railways of British India. (1,900 words & fig.)

Engineering. (London)

1907 **625** .13
Engineering, No. 2154, April 12, p. 473.

PRELINI (C.). — The New York subaqueous tunnels. (4,500 words & fig.)

1907 **656** .281
Engineering, No. 2154, April 12, p. 479.

The recent accident on the New-York Central & Hudson River Railroad. (4,000 words & fig.)

1907 **625** .616
Engineering, No. 2154, April 12, p. 482.

Narrow-gauge eight-wheel duplex locomotive. (450 words & fig.)

Engineering Magazine. (London.)

1907 **625** .13
Engineering Magazine, April, p. 1.

MUNBY (E. J.). — New York and Panama. A contrast in engineering achievement. (3,500 words & fig.)

Engineering News. (New York.)

1907 **625** .151
Engineering News, No. 13, March 28, p. 356.

Switch-closing devices and switch protection on main tracks. (2 000 words.)

1907 **624**. (01
Engineering News, No. 14, April 4, p. 372.

MCKIBBEN (F. P.). — Maximum live-load bending moments and shears for bridges carrying electric cars. (1,200 words, 1 table & fig.)

1907 **656** .234 (.73)
Engineering News, No. 15, April 11, p. 406.

Concerning a railway passenger rate of two cents per mile. (1,800 words.)

1907 **621** .132.3 (.42) & **621** .132.5 (.42)
Engineering News, No. 16, April 18, p. 411.

The design of recent English locomotives. (2,700 words, 2 tables & fig.)

1907 **656** .25 (01
Engineering News, No. 16, April 18, p. 415.

ELLIOTT (W. H.). — Unsettled questions in railway signaling. (4,500 words & fig.)

1907 **385** .113
Engineering News, No. 16, April 18, p. 419.

ANDREWS (F.). — Costs of hauling crops from farms to shipping points. (2,800 words & 1 table.)

1907 **625** .24 (01
Engineering News, No. 16, April 18, p. 425.

MUHLFELD (J. E.). — Practical means for increasing the earning capacity of freight cars. (1,600 words.)

Indian Engineering. (Calcutta.)

1907 **313** : **656** .28 (.54)
Indian Engineering, No. 14, April 6, p. 214.

Railway accidents. (1,800 words & 1 table.)

Journal of the Western Society of Engineers. (Chicago.)

1907 **621** .33
Journal of the West. Society of Engin., No. 1, February, p. 1.

ARNOLD (B. J.). — The progress of electricity on steam roads in 1906. (5,800 words.)

1907 **624** .8

Journal of the West. Society of Engin., No. 1, February, p. 13.

Design of swing bridges, from a maintenance standpoint. (24,500 words & fig.)

1907 **62.** (01 & **721** .9

Journal of the West. Society of Engin., No. 1, February, p. 100.

CONDRON (T. L.). — Tests of bond between concrete and steel. (3,600 words, 4 tables & fig.)

1907 **656** .212

Journal of the West. Society of Engin., No. 1, February, p. 118.

NORTH (H. M.). — The theory of the design of railway freight terminals. (10,500 words & fig.)

Locomotive Journal. (Leeds.)

1907 **385** .112

Locomotive Journal, No. 4, April, p. 161.

Estimating the cost of railway ways and works. (3,000 words & 2 tables.)

Locomotive Magazine. (London.)

1907 **621** .135.5

Locomotive Magazine, No. 176, April 15, p. 66.

The brake rigging of modern locomotives. 550 words & fig.)

1907 **621** .132.8

Locomotive Magazine, No. 176, April 15, p. 72.

Steam rail motor coach, Central South African Railways. (300 words & fig.)

Proceedings of the American Society of Civil Engineers. (New York.)

1907 **62.** (01 & **691.** (01

Proceed. of the Amer. Soc. of Civil Eng., No. 3, March, p. 222.

FULLER (W. B.) & THOMPSON (S. E.). — The laws of proportioning concrete. (16,800 words, tables & fig.)

Proceedings of the Institution of Civil Engineers. (London.)

1906/7 **621** .33

Proceedings of the Inst. of Civil Eng., vol. CLXVII, pt I, p. 28.

JENKIN (C. F.). — Single phase electric traction. (22,500 words, 4 tables & fig.)

1906/7 **624** .62

Proceedings of the Inst. of Civil Eng., vol. CLXVII, pt I, p. 343.

FREEMAN (R.). — The design of a two-hinged spandrel-braced steel arch. (3,800 words, tables & fig.)

Railroad Gazette. (New York.)

1907 **621** .132.8

Railroad Gazette, No. 13, March 29, p. 451.

Ganz steam motor car for the Rock Island. (400 words & fig.)

1907 **656** .256 (.73)

Railroad Gazette, No. 14, April 5, p. 479.
— No. 16, — 19, p. 544.

Government report on the block system. (10,000 words & fig.)

1907 **625** .13

Railroad Gazette, No. 15, April 12, p. 512.

COUNTY (A. J.). — Pennsylvania Railroad tunnel extension into New York City. (3,400 words & fig.)

1907 **625** .13

Railroad Gazette, No. 15, April 12, p. 521.

LAHMER (J. A.). — The sixth street viaduct at Kansas City. (1,700 words & fig.)

1907 **625** .232

Railroad Gazette, No. 16, April 19, p. 541.

All-steel Pullman sleeping car. (450 words & fig.)

1907 **656** .28 (01 (.42)

Railroad Gazette, No. 16, April 19, p. 548.

YORKE (H. A.). — British practice in railroad accident inquiries and railroad inspection. (1,600 words.)

Railway Age. (Chicago.)

1907 **725** .33

Railway Age, No. 1607, March 29, p. 534.

Chicago & Western Indiana locomotive terminal at Chicago. (1,000 words & fig.)

1907 **621** .132.8

Railway Age, No. 1607, March 29, p. 543.

Ganz steam motor car for the Rock Island. (400 words & fig.)

1907 **621** .132.3

Railway Age, No. 1608, April 5, p. 572.

New locomotives for the National Railway of Mexico. (800 words & fig.)

1907 **725** .43

Railway Age, No. 1609, April 12, p. 597.

The new locomotive repair shops of the Lackawanna Railroad at Scranton, Pa. (3,000 words & fig.)

1907 **621** .132.6

Railway Age, No. 1609, April 12, p. 607.

Tank locomotive for the Nevada Northern. (500 words & fig.)

Railway Engineer. (London.)

1907 **625** .241

Railway Engineer, No. 327, April, p. 103.

40-ton rail wagon with 5 bolsters; North Eastern Railway. (500 words & fig.)

1907 **621** .133.2

Railway Engineer, No. 327, April, p. 109.

Flexible firebox stays. (3,000 words & fig.) (S. *Bulletin of the Railway Congress*, No. 1, January 1907.)

1907 **656** .255

Railway Engineer, No. 327, April, p. 118.

Miniature electrical train-staff. (700 words & fig.)

Railway and Engineering Review. (Chicago.)

1907 **625** .111

Railway and Engineering Review, No. 12, March 23, p. 240.

Economics of railway location. (2,800 words.)

1907 **385**. (07.2 (.73)

Railway and Engineering Review, No. 12, March 23, p. 242.

Engineering laboratories of the university of Pennsylvania. (7,000 words & fig.)

1907 **725** .33

Railway and Engineering Review, No. 13, March 30, p. 265.

Chicago & Western Indiana engine terminal. (2,200 words & fig.)

Railway Gazette. (London.)

1907 **625** .216

Railway Gazette, No. 14, April 5, p. 318.

Automatic railway couplings. (700 words & fig.)

1907 **656** .231 & **656** .235

Railway Gazette, No. 14, April 5, p. 322.

MARRIOTT (H.). — The fixing of rates and fares. (1,400 words & tables.)

1907 **656** .281

Railway Gazette, No. 14, April 5, p. 326.

Comparative effects of steam and electric locomotives on a 3-deg. curve. (1,000 words, 4 tables & fig.)

1907 **625** .151

Railway Gazette, No. 15, April 12, p. 344.

Taylor's patent shunting lever. (600 words & fig.)

Railway and Locomotive Engineering. (London.)

1907 **621** .335

Railway and Locomotive Engineering, April, p. 172.

Illinois traction locomotive. (700 words & fig.)

1907 **621** .134.3

Railway and Locomotive Engineering, April, p. 178.

KENNEDY (J.). — Adjusting Stephenson valve gear. (2,200 words & fig.)

Railway Magazine. (London.)

1907 **625** .216

Railway Magazine, No. 118, April, p. 265.

ALLEN (C. J.). — Slipping the slip. An account of how slip coaches are detached from our express trains. (2,200 words & fig.)

1907 **725** .32

Railway Magazine, No. 118, April, p. 273.

WEST (F. W.). — The Crewe tranship shed. What it means to the L. & N. W. Railway and the trading public. (2,500 words & fig.)

1907 **656** .222.1 (.42)

Railway Magazine, No. 118, April, p. 318.

ROUS-MARTEN (C.). — British locomotive practice and performance. (3,400 words & fig.)

Railway Master Mechanic. (Chicago.)

1907 **625** .245

Railway Master Mechanic, No. 4, April, p. 115.

New air brake instruction car C. B. & Q. Ry. (700 words & fig.)

Railway News. (London.)

1907 **385** .15

Railway News, No. 2257, April 6, p. 668.

The nationalisation of railways. (3,500 words.)

Railway Times. (London.)

1907 **656** .283

Railway Times, No. 17, April 27, p. 426.

The Arbroath collision (1,400 words & fig.)

Street Railway Journal. (New York.)

1907 **621** .335

Street Railway Journal, No. 14, April 6, p. 575.

VALATIN (B.). — Three-phase locomotive with three ranges of speed for the Italian State Railways. (2,000 words & fig.)

1907 **621** .14 & **621** .132.8

Street Railway Journal, No. 14, April 6, p. 607.

Pennsylvania Railroad Commission reports unfavourably on road motor cars as an auxiliary in American passenger service — also reports on rail motor cars. (1,600 words.)

1907 **625** .143.3
Street Railway Journal, No. 15, April 13, p. 640.

PANTON (J. A.). — Rail corrugation. (5,600 words & fig.)

In Italian.

Bollettino delle finanze, industrie, commercio, lavori pubblici, appalti. (Roma.)

1907 **656** .235.7
Bollettino delle finanze, nº 32, 21 aprile, p. 585.

I trasporti agricoli per ferrovia. (1,300 parole.)

1907 **385** .4 (.45)
Bollettino delle finanze, nº 33, 28 aprile, p. 597.

La legge sull' ordinamento delle ferrovie. (2,200 parole.)

Ingegneria ferroviaria. (Roma.)

1907 **385** .4 (.45)
Ingegneria ferroviaria, nº 7, 1º aprile, p. 101.

MARTORELLI (F.). — L'ordinamento definitivo delle ferrovie di Stato. (2,200 parole.)

1907 **621** .132.3
Ingegneria ferroviaria, nº 7, 1º aprile, p. 105.

FAVRE (E.). — Le particolarita' delle locomotive americane acquistate dalle ferrovie dello Stato nel 1906. (2,200 parole & fig.)

1907 **385** .15 (.494)
Ingegneria ferroviaria, nº 7, 1º aprile, p. 110.

GERLI (E.). — Il riscatto della linea del Gottardo e gli interessi italiani. (3,200 parole.)

1907 **621** .335
Ingegneria ferroviaria, nº 7, 1º aprile, p. 112.

I locomotori gruppo 36 delle ferrovie elettriche Valtellinesi. (700 parole & fig.)

1907 **621** .133.1
Ingegneria ferroviaria, nº 8, 16 aprile, p. 121.

CERRETI (U.). — Il combustibile liquido sulle locomotive. (700 parole & fig.)

In Dutch.

Ingenieur. ('s Gravenhage.)

1907 **625** .111
Ingenieur, nr 16, 20 April, p. 276.

Spoorwegverbindingen om Amsterdam. (25,000 woorden, 3 tafereelen & fig.)

1907 **621** .33
Ingenieur, nr 17, 27 April, p. 303.

FELDMANN (C.). — Aanleg en constructie van den werkdraad voor wisselstroombanen. (1,200 woorden & fig.)

Locomotief. (Rotterdam.)

1907 **385** .15
Locomotief, nr 27, 3 April, p. 209.

Staatsexploitatie van spoorwegen. (2,800 woorden.)

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BULLETIN

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[656 .253]

NOTE

ON THE

STANDARD CONVERTIBLE SEMAPHORE SIGNALS OF THE BELGIAN STATE RAILWAYS,

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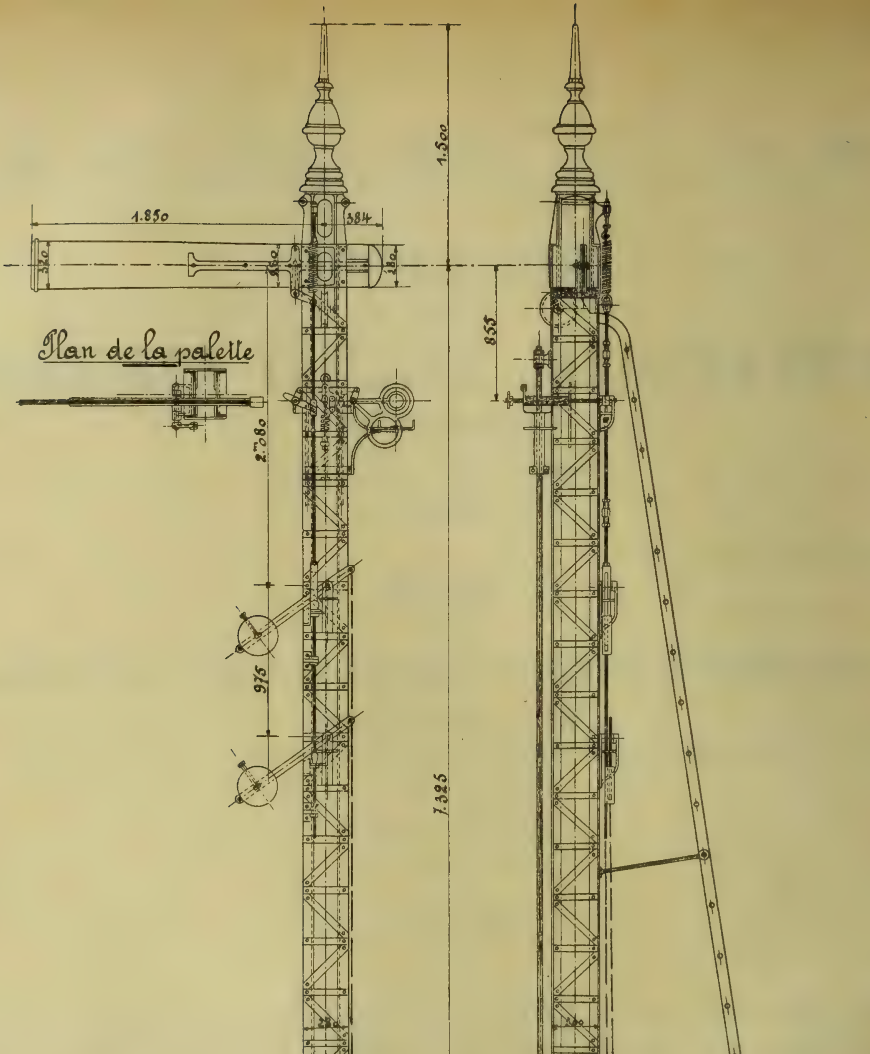
Figs. 1 to 85, pp. 668 to 707.

PREFACE.

The first semaphores used by the Belgian State Railways were supplied by the firm of Saxby & Farmer of London, who constructed the complete equipment for the principal stations. These semaphores closely resembled those in general use throughout England. They were of various types. The posts were of lattice work and those of the latest type were tapered. On the first lines fitted with the block system, a large number of semaphores with tubular posts and a single arm are found however; these were made by Messrs. Siemens & Halske of Berlin and were supplied with the earliest Belgian installations of electric block signalling.

When, at a comparatively recent date, the Administration commenced to construct and erect semaphores at the big junctions contiguous to the main stations, it was thought advisable to prepare standard types, the drawings of which served as a basis for all subsequent applications up to 1903. The majority of these drawings are dated 1893 and 1894.

Figures 1 to 5 give a general idea of one of the most simple cases of this early type (post with one arm single slotted and with movable oil lamp). It is to be noted that in order to simplify the construction, no taper is given to the post. The foot was of cast iron which has certain advantages in respect to durability when



Figs. 1 to 5. — Semaphore, old pattern (1894 type). Post with one arm, single slotted, with movable lantern and oil lamp. Scale : $^1/_{50}$.

Explanation of French terms : Coupe en plan du pied = Section (plan) of foot. — Plan de la palette = Plan of arm.

embedded in the ground. An equally satisfactory result, it is true, can be arrived at in the worst ground (sulphurous cinders) with a foot built up of rolled sections and embedded in concrete. The semaphore is then, however, difficult to move.

The crown piece, though of good æsthetic appearance, is much too heavy for the general design of the semaphore. This defect is especially noticeable in the carriage. The method of constructing the lattice work with the lattice bars placed outside the angles, is also open to criticism. The angle irons forming the verticals were too much weakened by the arrangement adopted, and thel attice bars required "joggling" or making flush with considerable increase in first cost and no actual advantage.

These difficulties became largely increased when the post carried a number of arms and when the lattice work had to carry a considerable number of slot gears.

The lamp guides were not stiff enough, and when tightened, the post bent like a bow.

It should be noted that the centre of the arm was placed below the centre; consequently, the mass had an eccentric movement which gave rise to shock.

Finally, if any fracture or disconnection occurred to the operating gear, the signal went to line clear. This defect was common also to the earlier English signals and our British neighbours altered this some years since, under pressure from the *Board of Trade*, which required them to fix a counterpoise on the short end of the arm sufficient to return this to danger under such conditions. This remedy, which has the disadvantage of increasing the load on the spindle of the arm, can only be applied to our signals of the 1894 pattern by reversing the action of the operating gear, and this is equivalent to reconstructing the whole. In the later patterns of semaphore, the problem has been solved by adopting the "rising" arm instead of the "falling" arm.

The semaphores of the 1893-1894 type, moreover, do not admit of the application of the double wire control; this is the only method which ensures precise correspondence between the position of the arm and the position of the actuating lever.

The defects which we have mentioned above, and others which an experience extending over a period of ten years has revealed, are however of quite secondary importance compared with another defect which is paramount; this is the difficulty of supply and the impossibility of carrying a stock of signals.

Each semaphore before being made had to be specially drawn so as to give particulars of :

The number and kind of arms;
The number of slots;
The method of lighting (gas or oil, fixed lamp or movable lamp);
The leads for the wires from the foot of the post.

It follows that when a new group of signals had to be arranged delays occurred which were aggravated, firstly because the whole of the original installation had to be left intact up to the last moment before putting in the new installation (so as to cause the minimum of trouble to the traffic department) and secondly, because the by-laws and regulations, by means of which the State secures the adoption of such changes, generally take some time to come into effect.

The basis of the new programme was, therefore, as follows : *required to be able to construct any semaphore suitable for any requirement of the traffic by means of interchangeable components carried as such in stock.*

The necessity for this has become even more pronounced since the Belgian State Railways have attempted gradually to improve their signalling system, and this has led to the introduction of the new type of post known in that country as the " candlestick " type.

Before proceeding with a detailed description of the universal semaphores, we will give some extracts from the new general signalling regulations dealing with semaphores and their use.

CHAPTER I.

Use of semaphores for signalling on the Belgian State Railways (1).

1. — Function and position of semaphores.

Semaphore signals are used at :

1° Junctions and stations, to protect those places which engine drivers cannot reach without danger when the road is not clear.

Semaphores are placed at least 60 metres (65 yards) from such places (2).

2° On the main line and at stations, to ensure the proper distance being kept between trains running on the same track and dividing the track into block sections. These block semaphores are placed at the commencement of each section near the place occupied by the " block cabin ".

At intermediate stations, the block semaphores are placed at the end of the platform; on the open track, they are placed near the cabin.

3° In advance of certain semaphores as repeating arms; these are caution signals; they are placed about 1,000 metres (1,090 yards) in advance of the signals they repeat (3).

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(1) This chapter is extracted from the new general regulations for signals on the Belgian State Railway, at the present time in the press.

(2) It has been decided to place, on trial, distant signals, known also as caution signals, which can be overrun, at a distance of 300 metres (328 yards) in advance of such signals. We think that experience will prove this distance to be too great, and that it will involve much complication and difficulty in signalling.

(3) We are of opinion that this distance also will be found to be rather too great in practice.

2. — Component parts of a semaphore. — Types of arm. — Colours of lights.

A semaphore consists of at least one arm, which turns about a horizontal axis; it is placed on the left hand side of the post as seen from an arriving train. The running staff have therefore only to notice those signals which are on the left of each post which they pass.

The arm may occupy two positions : the one horizontal and the other inclined (either upwards or downwards) (¹). A lamp carried on a bracket at the height of the arm shows coloured lights front and back (²) according to the position of the arm.

A block semaphore, moreover, is fitted with an arrangement for automatically placing a detonator on the rail when the arm is horizontal, so that the explosion may give warning that the signal has been passed.

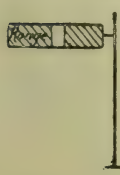

Fig. 6.

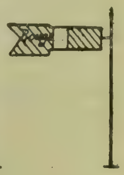

Fig. 7.

Explanation of French term : Rouge = Red.

Semaphore arms, other than caution arms, are generally of the shape of a long rectangle (fig. 6); but at junctions and in stations the arms which relate to tracks which can be run over at normal speed are cut with a V notch at the outer end as shown in figure 7.

The front face of each arm, that is to say, that which faces the arriving train, is the only one with which the engine driver is concerned; this face is red with a transverse white band. The back is white with a transverse black band.

The caution signals are cut to a V point at the outer end as shown in figure 8. The front face is yellow and the back is white with a transverse black band.

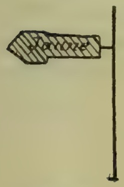

Fig. 8.

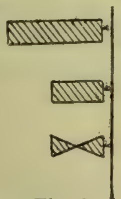

Fig. 9.

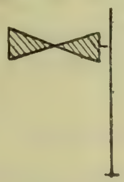

Fig. 10.

Explanation of French term : Jaune = Yellow.

There are also short arms of rectangular shape (³). These relate only to shunting operations and are known as *shunting arms*, or they relate to trains entering bays and are then known as *bay arms* (fig. 9).

Finally there are " backing-down arms " of the form of two triangles joined at the vertices; they only relate to trains which have to back down on to a main line carrying passenger traffic; such an arm is shown in figure 10.

(¹) In the new semaphores, the upward inclination is universal, but the old signals having downward inclination have not been altered; experience has shown that this difference causes no trouble whatever to the drivers.

(²) According to a recent regulation, the back light will in future be a small white light or a violet light and only visible when the arm is at danger.

(³) In some cases where it has been found necessary to carry a second arm on the same post for special shunting operations of short distance, the second arm has been made in the form of two triangles joined at the vertices.

Colours of lights. — The *horizontal* position of an arm of ordinary size (*other than a caution arm*) is marked at night by a *red* light, while the *inclined* position is marked by a *green* light (1), or by a *double green light* if the arm is cut out with a V notch, and allows the train to pass at normal speed.

The *horizontal* position of the *caution* arm (arm terminating in a V point) is shown at night *either by a red light side by side with a green light or by a yellowish orange light;* the *inclined* position of the caution arm is shown by a *double green light* in the first case and by a *single green* light in the second case (2).

At night the horizontal position of the *shunting arm* is shown by a *small red light* or by a *violet light*; the *inclined position* is shown by a *green light.*

In normal places, no light is shown for *shunting arms*, a hand lamp is held against the post when shunting takes place at night. A *red light* is shown when the arm is *horizontal* and a *green light* when it is inclined.

To draw the attention of drivers to the fact that they are approaching a caution signal, whitened posts are placed a short distance apart along the side of the route.

3. — Meaning of semaphore signals.

1° Arms other than caution arms or distant signals.

The *horizontal* position of any arm other than a caution (or distant) arm, shown at night by a *red light* means *stop*; the arm and semaphore of which it forms part are said to be at danger.

The inclined position of any arm other than a caution (or distant) arm, shown at night by a *green light* (or by a *pair of green lights* if the arm end is V notched) shows that the line is clear and means *proceed.* The *inclined* position of the V notched arm, shown at night by a pair of green lights, permits the train to proceed at normal speed.

2° Caution arms (distant signals).

In the case of caution (or distant) arms two cases have to be considered.

Firstly. When the caution arm is the only arm on the post.

The *horizontal* position shown at night, either by a *yellowish-orange light* or by a *red light and green light side by side* (2) shows that the succeeding semaphore is at danger, and permits the driver to proceed past the signal *with caution.*

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(1) The inclined position of block semaphore arms has hitherto been shown at night by a white light. The replacement of these by green lights is now in progress.

(2) The yellowish-orange light and the single green light are employed when the arm is preceded by either a fixed audible warning which acts in time of fog when the arm is horizontal, or by repeating lights, only lit in time of fog, showing a yellowish-orange light for caution and a green light for line clear. The audible warning will be placed 100 metres (109 yards) before the distant signal, but experiments on the subject are in progress. The repeating lights will also probably be placed at 100 metres (109 yards) in advance but experiments are in progress with a view to determining their number and position.

The *inclined* position — shown at night by a *green light* or by a *pair of green lights side by side* (1) means that the succeeding semaphore is at line clear and that the speed may be the maximum allowed at this particular part of the line.

Secondly. When danger signals are not far apart, the distant arm corresponding to one is placed on the same post as the preceding signal. Both arms then refer to the same track, the one being a danger signal and the other a caution (or distant) signal, and both of these must be observed by the driver.

The *horizontal* position of the danger arm — shown at night by a *red light* — and the *horizontal* position of the *caution* (or distant) arm shown at night by a *yellowish-orange light* (1) or by a *red light* (2) means *stop* (fig. 11).

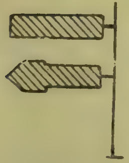
Fig. 11.
Stop.

The *inclined* position of the *danger* arm — shown at night by a *single or double green light* — and the *horizontal* position of the *caution* (or distant) arm shown at night either by a *yellowish-orange light* or by a *red light side by side with a green light* — means that the succeeding danger arm is at danger and allows the driver to proceed past the signal with caution (fig. 12).

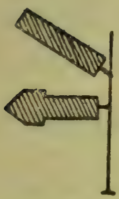
Fig. 12.
Caution.

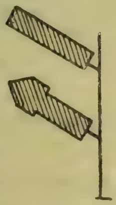
Fig. 13.
Line clear.

The *inclined* position of the *danger* arm — shown at night by a *single or double green light* — and the *inclined* position of the *caution* (or distant) arm shown at night by a *green light* or *two green lights side by side* (1) — show that the succeeding danger arm is at line clear and permits the driver to proceed at the maximum speed allowed at this particular part of the line (fig. 13).

The caution (or distant) arm can only take the inclined position when the danger arm is itself inclined.

4. — Relation between signal arms and tracks at junctions and in stations.

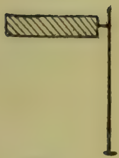
Fig. 14.
Stop.

At junctions and in stations, the direction in which the train is required to proceed is shown by the semaphores by one of the three following methods :

1° *By means of number plates* operated in conjunction with a single arm; the semaphore is known as a *track number semaphore*. The numbers may be either figures or letters, which relate to the direction of the tracks, and are described in the running instructions. With the arm at danger the numbers are not visible to the driver (fig. 14); when the arm is at line clear, a number is shown which shows on what track the driver will proceed (fig. 15).

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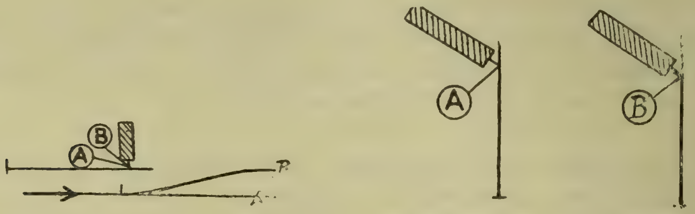
(1) *See* footnote (2) on preceding page.

(2) The red light is actually side by side with a green light in this case, but this is screened off by a shutter to avoid any chance of confusing the driver who is required to stop.



Line clear
for track A.

Line clear
for track B.

Fig. 15.

This method of indicating by numbers the track on which the driver will proceed, is only used when the trains arrive at the semaphore with a speed of 40 kilometres (24·9 miles) per hour or under.

It is applied particularly to the starting arms at stations, and to the arms protecting sidings or to tracks on which all trains stop.

2° *By means of arms placed one above the other on the same post;* the semaphore is then known as a *multiple arm semaphore.*

The uppermost arm relates to the extreme left track from the main line; the next lower arm relates to the next track to the right of the first; and so on down to the lowermost arm which refers to the track to the extreme right.

For example, at a three track junction (*see* fig. 16):

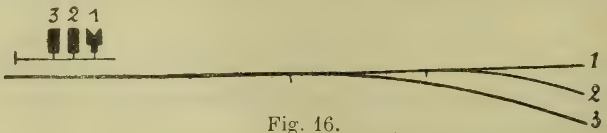


Fig. 16.

the upper arm 1 relates to the left hand track 1; the middle arm 2 relates to the middle track 2; and the lower arm 3 to the right hand track 3.

Semaphores with superposed arms have been made with as many as five or six arms; but in more recent installations, an endeavour has been made to limit the number to a maximum of three on any one post by combining this system with that of numbers.

For example, at the entrance to a station the arrangement shown in figure 17 may occur :

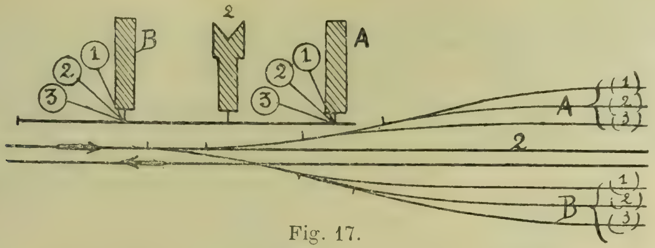


Fig. 17.

The arm A refers to the branch giving access to the group of tracks A. Number 1 appears when the points are set for track (1) of group A, number 2 when the points are set for track (2) of A and the number 3 when the points are set for track (3) of A. The arm 2 relates to the main track 2; and the arm B to the line leading to the group of tracks B; the number 1 is shown when the points are set for track (1) of B; the number 2 when the points are set for track (2) of B and the number 3 when the points are set for track (3) of B.

The use of semaphores with superposed arms which was formerly general on the Belgian State Railway, is being gradually abandoned. Semaphores in which the arms are arranged horizontally, are now being installed (*see* below).

3° *By means of arms arranged horizontally and carried by a common base*; this form is known as the *candlestick semaphore*.

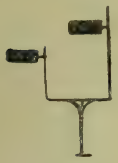


Fig. 18.

This pattern consists of short posts each carrying a single arm; these short posts rise from a horizontal member supported by a common base piece (fig. 18), the whole having the appearance of a candlestick.

This candlestick pattern is not used with a greater number than three posts.

The left arm on the left hand post relates to the track or group of tracks situated furthest to the left of the main line; the arm on the central post relates to the central track or group of tracks and the arm on the right relates to the right hand track or group of tracks.

The arm which relates to the most important track is placed rather higher than the others (1); this arm is, moreover, cut out with a V notch at the end and at night shows a double green light if the track to which it relates can be run over at the normal speed allowed on the line (2).

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(1) The arms are spaced vertically 2·19 metres (7 ft. 2 $^1/_4$ in.) from the cross member. The additional height given to the most important arm is also 2·19 metres (7 ft. 2 $^1/_4$ in.).

(2) The Belgian State Railway is carrying out the necessary works for avoiding the slackening of speed

In cases where more than three directions have to be protected, numbers are added to the posts which correspond to tracks over which the speed does not exceed 40 kilometres (24·9 miles) per hour.

The use of arms arranged horizontally to show the direction, is only enforced in the case of new installations or of important alterations in existing installations.

For example, at a simple junction with only two tracks the arrangement shown in figure 19 would be employed.

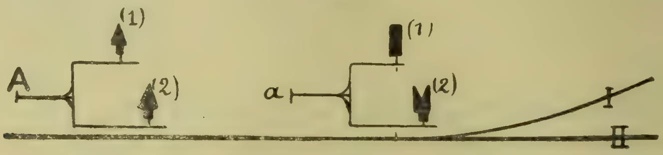

Fig. 19.

The arm (1) of *a* and its distant arm (1) of A relate to track I; the arm (2) of *a* and its distant arm (2) of A relate to track II.

The arrangement shown in figure 20 is another case, and relates to the approach to a station.

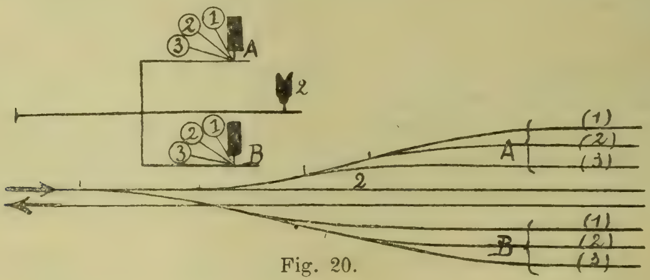

Fig. 20.

The left hand arm relates to the approach to the groups of tracks A; the number 1 is shown when the points are set for track (1) of A, the number 2, when the points are set for track (2) of A and the number 3 when the points are set for track (3) of A; the arm 2 relates to the main track 2; and the arm B to the approach to the group of tracks B; the number 1 is shown when the points are set for track (1) of B; the number 2 when the points are set for track (2) of B, and the number 3 when the points are set for track (3) of B.

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at junctions. When these are completed, it will be possible to do away with the V notch (and also the double green light). Slackening at special places (swing-bridges, etc.) will as heretofore be marked by a special board giving the reduced speed; generally this board is not lighted at night.

5. — Shunting arms showing the track cleared.

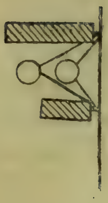


Fig. 21.

The small shunting arms may, like the ordinary arms, be used in conjunction with number plates to show to which track they relate.

Sometimes the same arrangement of numbers is worked in conjunction with an ordinary arm and a small shunting arm; this is shown diagrammatically in figure 21.

6. — Arms with the letter M or with a ring.

To draw attention to the fact that one arm of a semaphore with superposed arms relates to a siding or to a main line on to which trains are backed during shunting operations, an M cut out of sheet is fixed to the arm (fig. 22).

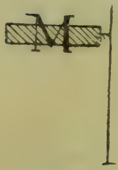


Fig. 22.

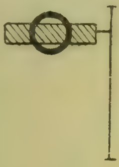


Fig. 23.

At the present time on semaphores of this class, a ring is fitted instead of the M (fig. 23).

This sign is also used to mark an arm which placed alone on a post relates to a siding or group of sidings.

In new installations an arm which gives the signal for backing down or running in the opposite direction to the normal is made in the form of two triangles connected at the vertices (*see* fig. 10 above).

7. — Arms for end of route.

When the route protected by a signal comprises points, crossings, etc., spread over a fairly long stretch of track (200 to 250 metres [220 to 275 yards]) the end of this section is marked by an arm for the end of the route, of the ordinary form (*see* fig. 6 above). Advantage is frequently taken to place this on the post carrying the signals relating to trains running in the opposite direction, since it has been thought that such signals can be placed without appreciable disadvantage on the right hand side of the track.

The end of route signal is put to line clear at the same time as or before that placed at the commencement of the route. It supplements the permission given to the driver at the commencement of the route, and confirms to him that the route remains the same while he passes over it. Should this arm be put to danger, the driver is immediately warned of emergency requiring him to stop.

Finally, this arm enables the station staff to know exactly on which track the train will arrive; to the signalmen it shows, in the case of large stations, the position occupied by the electric contacts (called " treadles ") with insulated rails which interlock the route until the last vehicle has passed over them.

End of route arms may be employed for shunting operations. They are then naturally of the form shown in figure 9 above. It is evident, in this case, that it is not necessary for the trains or engine to have covered the whole route and to have arrived at the post marking the end of the route, or that which shows the route to be taken, before the route may be changed. Such operations are made actually under the superintendence of the station master and he must give such orders in writing or verbally as will ensure safe working.

8. — Arrangement of semaphores at ordinary junctions.

A junction is protected, on the side from which the branches converge by a distant signal and a semaphore situated at least 60 metres (65 yards) from the place which the drivers can occupy without danger when the line is not clear. In the direction of the common main line, the junction is protected by a distant signal and a semaphore situated at least 60 metres (65 yards) in advance of the points (*see* fig. 24).

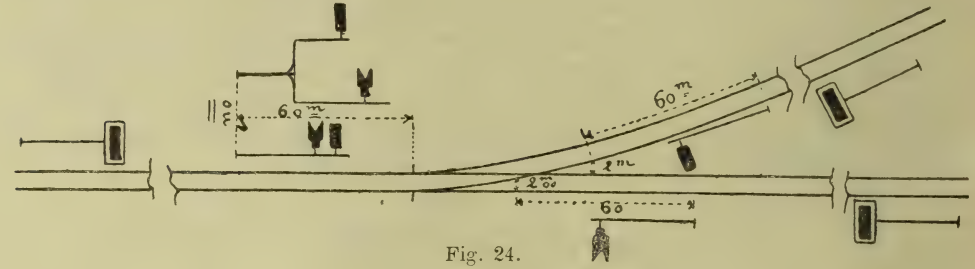


Fig. 24.

Explanation of French term : Ou = Or.

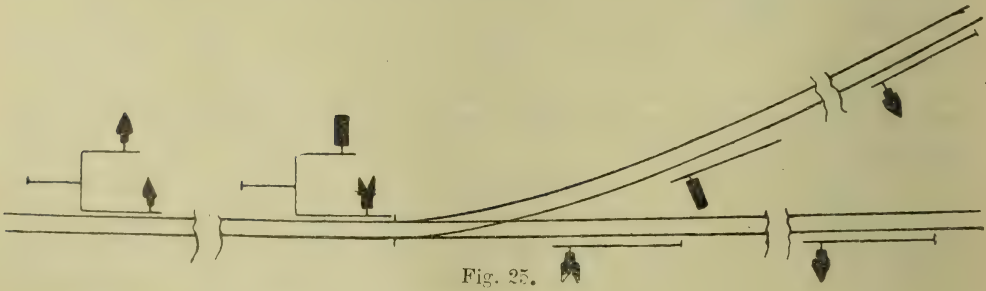


Fig. 25.

The use of candlestick semaphores is required for all new installations or in the case of important alterations to existing installations.

In future installations, caution (or distant) arms will be used in place of the old distant signals and the arrangement shown in figure 25 will be adopted.

9. — Arrangement of semaphores at triangular junctions.

Two or more junctions may be too close together to permit of conveniently placing distant signals between them. In this case the post of the danger semaphore of the one also carries the distant signal for the next.

To effect this, the corresponding arm is slotted, that is to say that to pull it off requires the cooperation of the men in both cabins. Figure 26 gives an example of this.

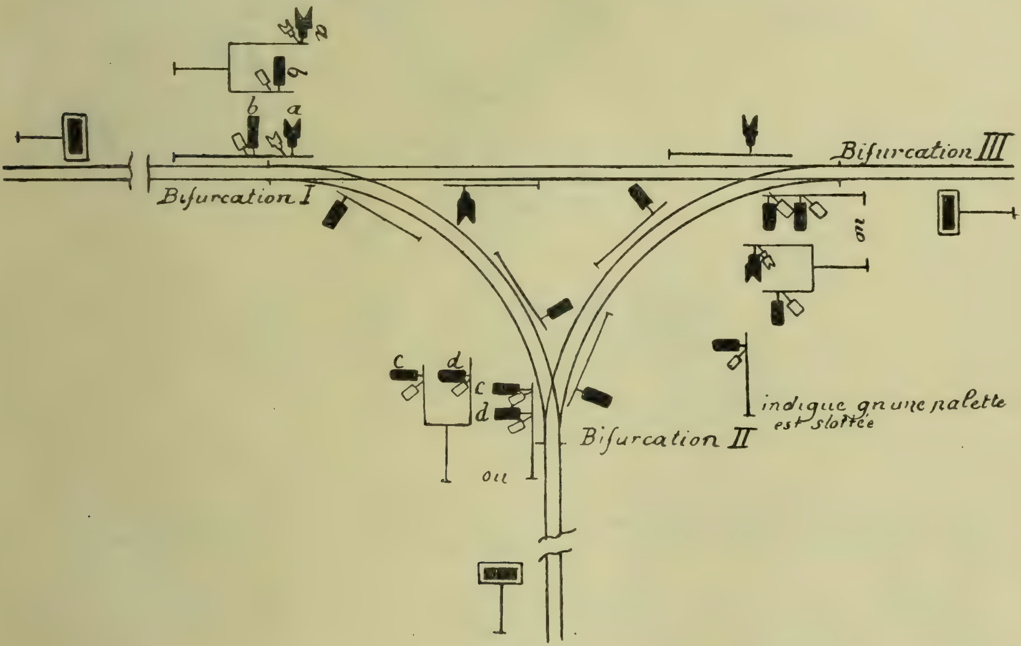


Fig. 26.

Explanation of French terms : Bifurcation I, II, III = Branch I, II, III. — Indique qu'une palette est slottée = Shows that the arm is slotted. — Ou = or.

The arm *a* serves as distant signal for branch III;
— *b* — — — II;
— *c* — — — I;
— *d* — — — III;
— *e* — — — II;
— *f* — — — I.

In the latest installations, caution arms are used instead of distant signals, and where two or more branches are too close to permit of the caution arms being placed between them, these are added on the posts at the junction. The arrangement given in figure 27 will show this.

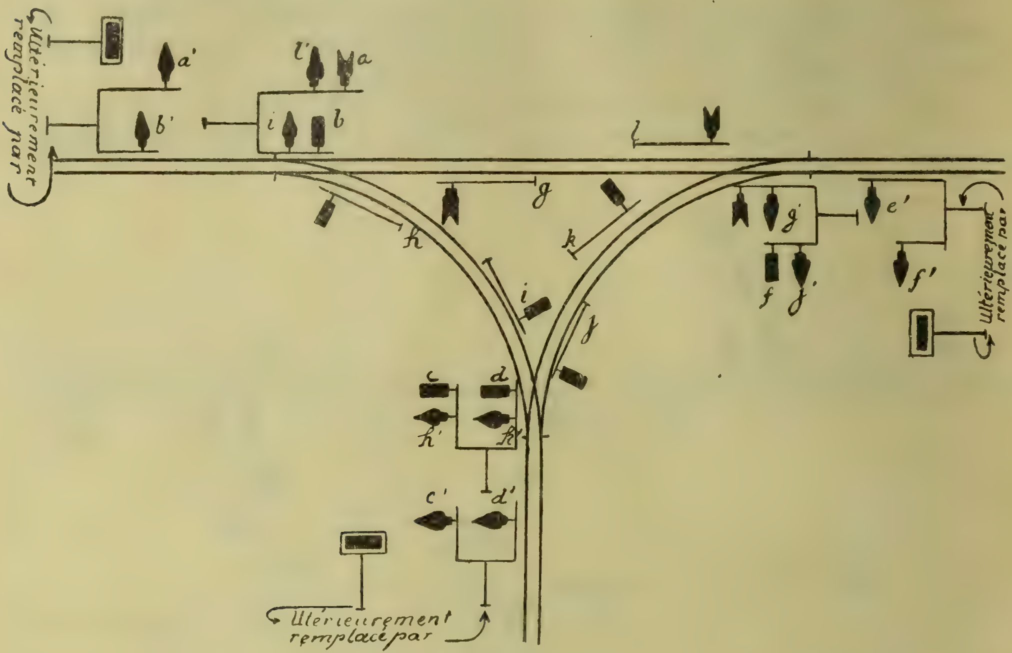

Ultérieurement remplacé par
a'
l'
a
b'
i
b
l
g
h
k
i
j
g'
e'
f
g'
f'
Ultérieurement remplacé par
c
d
h'
k
c'
d'
Ultérieurement remplacé par

Fig. 27.

Explanation of French terms : Ultérieurement remplacé par = Replaced later by.

10. — Arrangement of semaphores at junctions of a single track with a double track.

The plan of track and arrangement of signals where the single track leaves to the *right* of the double track are shown in figure 28. The doubling points A of the single track should be as near as possible to the signal cabin.

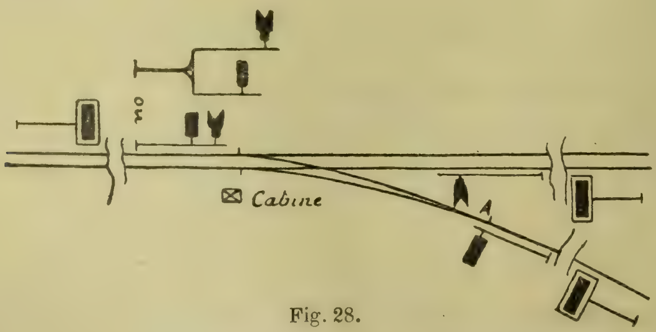


Fig. 28.

Explanation of French terms : Cabine = Cabin. — Ou = Or.

In the latest installations, distant signals are replaced by caution arms as shown in figure 29.

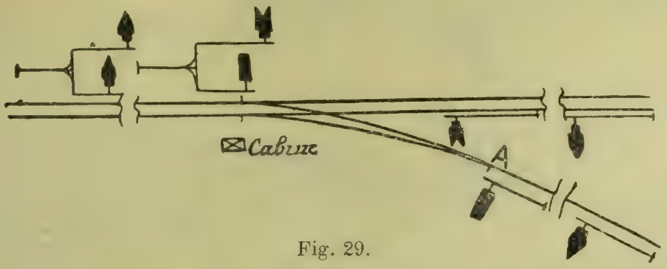


Fig. 29.

Explanation of French term : Cabine = Cabin.

The plan of track and arrangement where the single track leaves to the *left* of the double track, are shown in figure 30.

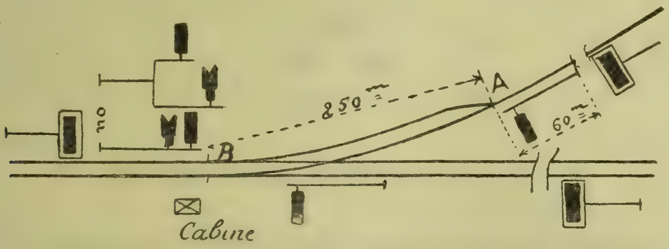


Fig. 30.

Explanation of French terms : Cabine = Cabin. — Ou = Or.

In the latest installations, distant signals are replaced by caution arms as shown in figure 31.

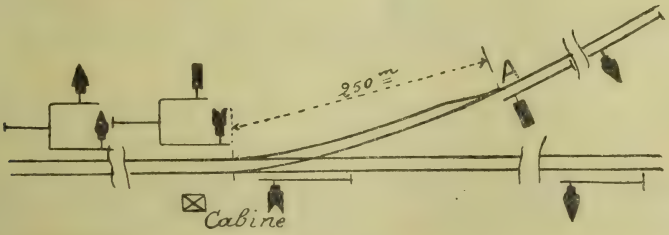


Fig. 31.

The double track is continued to such a distance that the doubling points A of the single track are about 250 metres (275 yards) from the cabin; by this arrangement, in the event of a main line train overshooting a signal set at danger, the whole length A B must be covered before collision could occur with a train coming from the single track branch.

11. — Arrangement of semaphores on entering large stations.

The approach to a station is shown in figure 32.

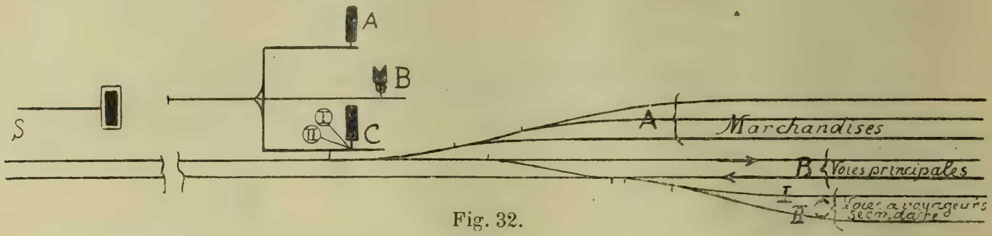


Fig. 32.

Explanation of French terms : Marchandises = Goods. — Voies principales = Main lines. Voies à voyageurs secondaires = Auxiliary passenger tracks.

In future installations, the distant signal S will be replaced by a caution arm of the type shown in figure 33.

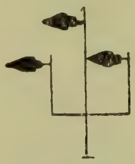
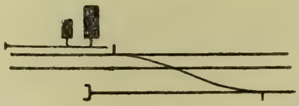


Fig. 33.

12. — Arrangement of semaphores at the approach to intermediate stations.

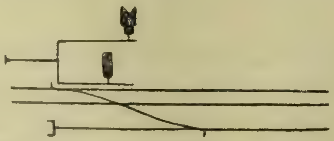
In the case of a station at which shunting operations are only performed exceptionally (say three or four times a week), the siding is protected by a small shunting arm described above (fig. 9).



Station at which shunting operations are effected.

Fig. 34.

In the case of a station at which shunting operations occur frequently, the approach is protected as a junction, a candlestick semaphore being installed (fig. 35).



Station at which shunting operations occur frequently.

Fig. 35.

CHAPTER II.

Description of the new semaphores.

Specification.

Apart from the essential feature that any of the new universal semaphores are capable of being built up out of standard interchangeable component parts carried in stock, they have been designed to meet the following requirements.

1° Each semaphore can be fitted with from one to three arms on the left side and independently from one to three arms on the right side;
2° Each arm can be slotted one or several times;
3° The control may be effected by the single wire and counterweight or by the double (endless) wire;
4° The lamps may be either fixed (gas) or movable (parrafin oil).

A. — Semaphores with superposed arms.

Each semaphore comprises the following main components shown in figures 36 to 48. Figures 36 to 45 are in the first instance shown as general arrangements to a scale of $^1/_{50}$. Some parts are again shown enlarged to a scale of $^1/_{20}$.

I. — Standard base, 1·85 metres (6 ft. $^{13}/_{16}$ in.) high, with frames for receiving the lead pulleys for the wires (figs. 36 to 39).
II. — Standard lower section of post, 1·82 metres (5 ft. 11 $^{11}/_{16}$ in.) high, in which the gear for raising and lowering the lantern can be subsequently fixed (*see* figs. 36, 37, 38 and 40).
III. — Standard lengthening pieces of which either one or two may be used; each of these is 2·19 metres (7 ft. 2 $^1/_4$ in.) long (*see* figs. 46 to 48).
IV. — Standard post, 6·43 metres (21 ft. 1 in.) high, arranged to take the arms and their controlling gear (figs. 36, 37 and 41 to 43).
V. — Standard crown piece (figs. 36 and 37).

I. *Standard base* (figs. 36 to 39). — The base is of cast iron. The frames containing the pulleys are all of a standard pattern and only differ from each other in the number of pulleys fitted. These frames fit on the flat upper surface of the base and are secured by four T headed bolts which are inserted from above through the rectangular holes in the top of the base (fig. 38). These holes are so arranged that the pulley frames can be placed in such manner as to allow the wires to be led from any one of the four sides of the post.

II. *Standard lower section of post* (figs. 36 to 43). (General arrangement.) — This part consists of four angle irons connected by gussets and by two steel brackets. It is attached to the base *by bolts* and is similarly connected to the post which comes next above it (figs. 36 and 37.)

The two steel brackets are prepared for receiving the lantern raising and lowering gear if this is required.

The lantern hoisting tackle comprises :

1° A winch (fitted with a toothed wheel), on which the steel wire rope which supports the lamp can be wound;

2° The winch spindle. This carries on the left hand end a toothed wheel for an automatic pawl and at the right hand end a crank handle;

3° A second winch geared to the first and operating a counterweight arranged to counter-balance the lamps; this is only fitted in the case of semaphores with three superposed arms. The diameter of this winch can be varied. The axes of the winches are arranged parallel to the track. The employee responsible for lighting up must face the side of the post remote from that along which the lanterns move; he operates the pawl with his left hand and the crank handle with his right hand. The risk of accident due to the lamps falling is therefore entirely eliminated.

The winches are built up of two pieces to facilitate their removal and renewal in case of damage.

III. *Standard lengthening or extension pieces* (figs. 46 to 48). — These lengthening pieces of a length equal to the vertical distance between two arms (that is 2·19 metres [7 ft. 2 $1/4$ in.]) can be inserted between the standard lower section and the post proper of the semaphore. They are secured to the adjacent posts by means of bolts.

Either none, one or two of these lengthening pieces may be used according to whether the semaphore is to carry one, two or three arms.

The lengthening pieces are fitted with guides for lowering the lamps (*see standard post*, below).

IV. *Standard post* (figs. 36, 37, 41 to 43 and 49). — The post or mast proper is a frustrum of a rectangular pyramid composed of four angle irons secured to each other by gussets.

It is arranged to receive one, two or three arms on the left side and also one, two or three arms on the right side; these may or may not be slotted.

The post is in any case fitted with guides for lowering and raising the lamps. Figure 49 shows the detail of the joint and mode of connecting these guides. Three stops fix the travel of the arms in each direction.

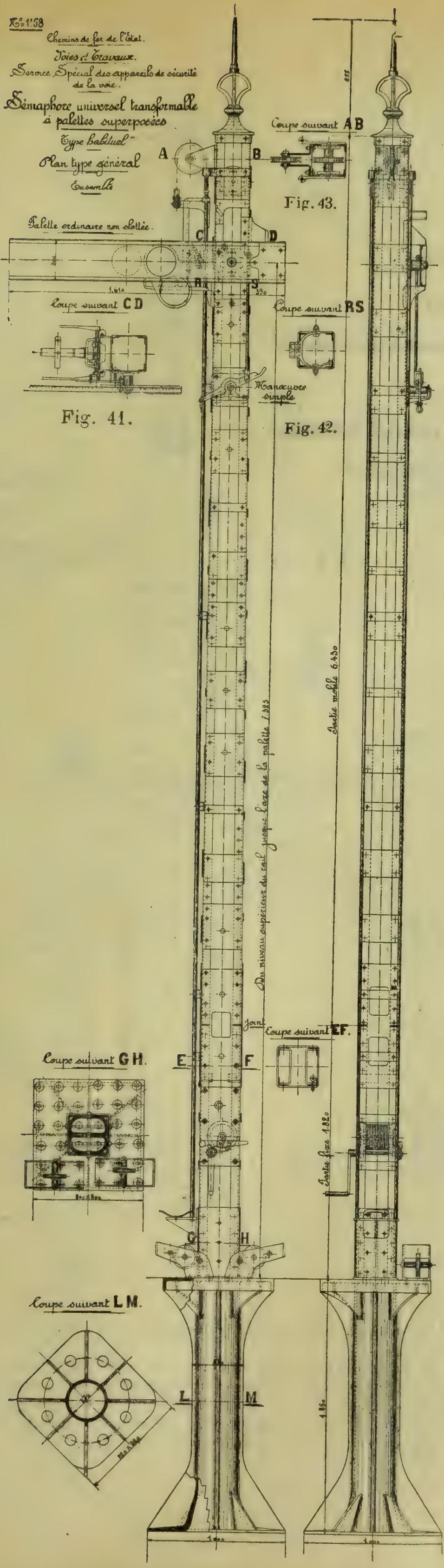


Fig. 43.

Fig. 41.

Fig. 42.

Fig. 36.

Fig. 37.

Explanation of French terms : Chemins de fer de l'État.— Voies et travaux. — Service spécial des appareils de sécurité de la voie. — Sémaphore universel transformable à palettes superposées. — Type habituel. — Plan-type général. — Ensemble = Belgian State Railway. Permanent way and Works Department. — Signals and safety appliances sub-department. — Universal transformable signal with superposed arms. — Normal type. — Standard pattern.— General arrangement. — Coupe suivant AB, CD .... = Section on AB, CD .... — Du niveau supérieur du rail jusque l'axe de la palette = From crown of rail to pivot of arm. — Joint = Joint. — Manœuvre simple = Simple control gear. — Palette ordinaire non slottée = Ordinary non slotted arm. — Partie fixe = Fixed part. — Partie mobile = Movable part.

Figs. 36 to 43. — General arrangement of universal transformable semaphore with superposed arms

No. 1158

Chemins de fer de l'État.

Voies et Travaux.

Service Spécial des appareils de sécurité de la voie.

Sémaphore universel transformable à palettes superposées

Type habituel

Plan type général

Ensemble

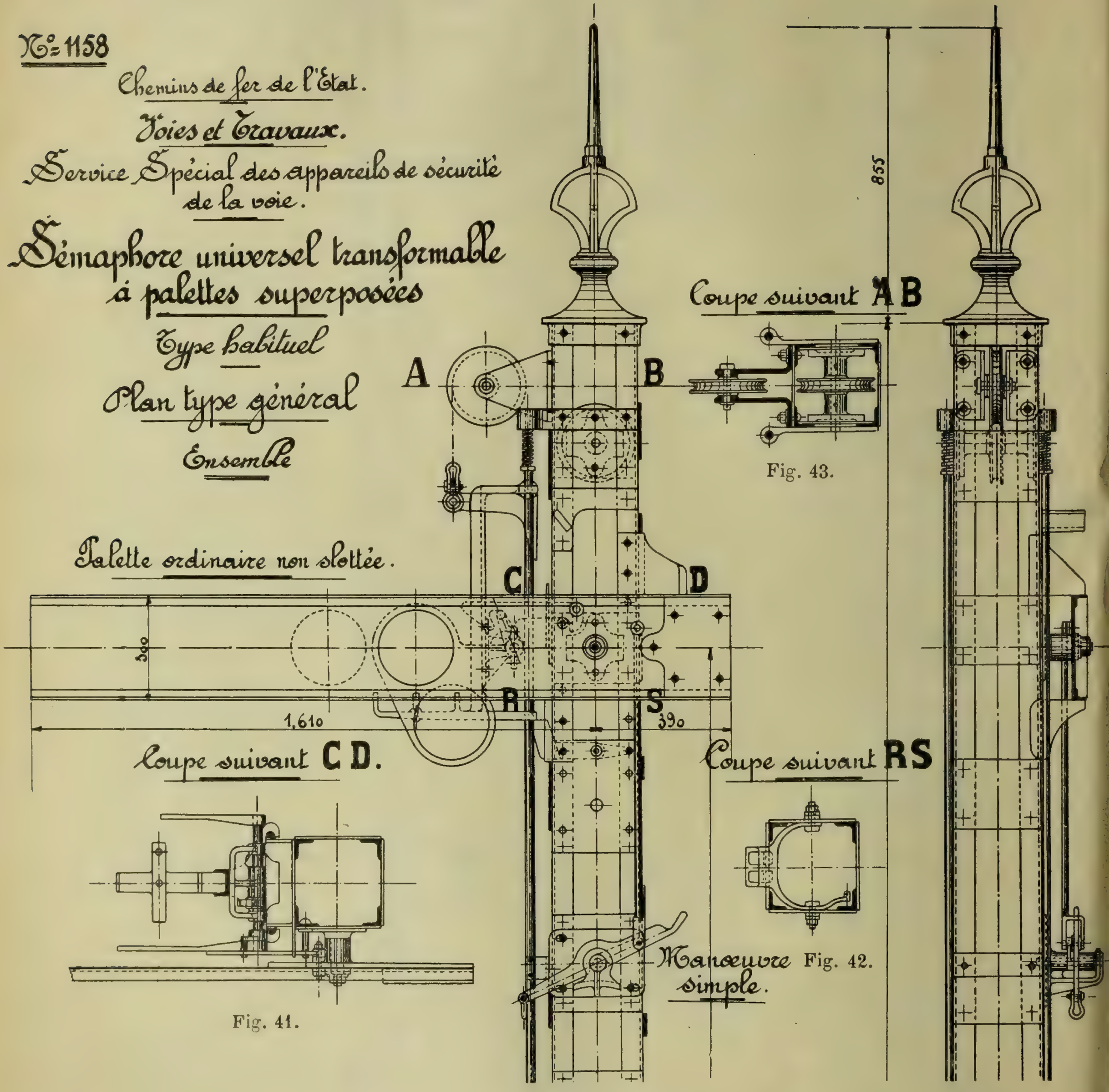


Fig. 43.

Fig. 41.

Fig. 42.

Fig. 36.

Fig. 37.

Figs. 36, 37 and 41 to 43. — Universal transformable semaphore with superposed arms. Standard post, scale : $^1/_{20}$.

Explanation of French terms : Chemins de fer de l'État. — Voies et travaux. — Service spécial des appareils de sécurité de la voie. — Sémaphore universel transformable à palettes superposées. — Type habituel. — Plan-type général. — Ensemble = Belgian State Railway. — Permanent way and Works Department. — Signals and safety appliances sub-department. — Universal transformable signal with superposed arms. — Normal type. — Standard pattern. — General arrangement. — Coupe suivant AB, etc. = Section on AB, etc. — Manœuvre simple = Simple control gear. — Palette ordinaire non slottée = Ordinary non-slotted arm.

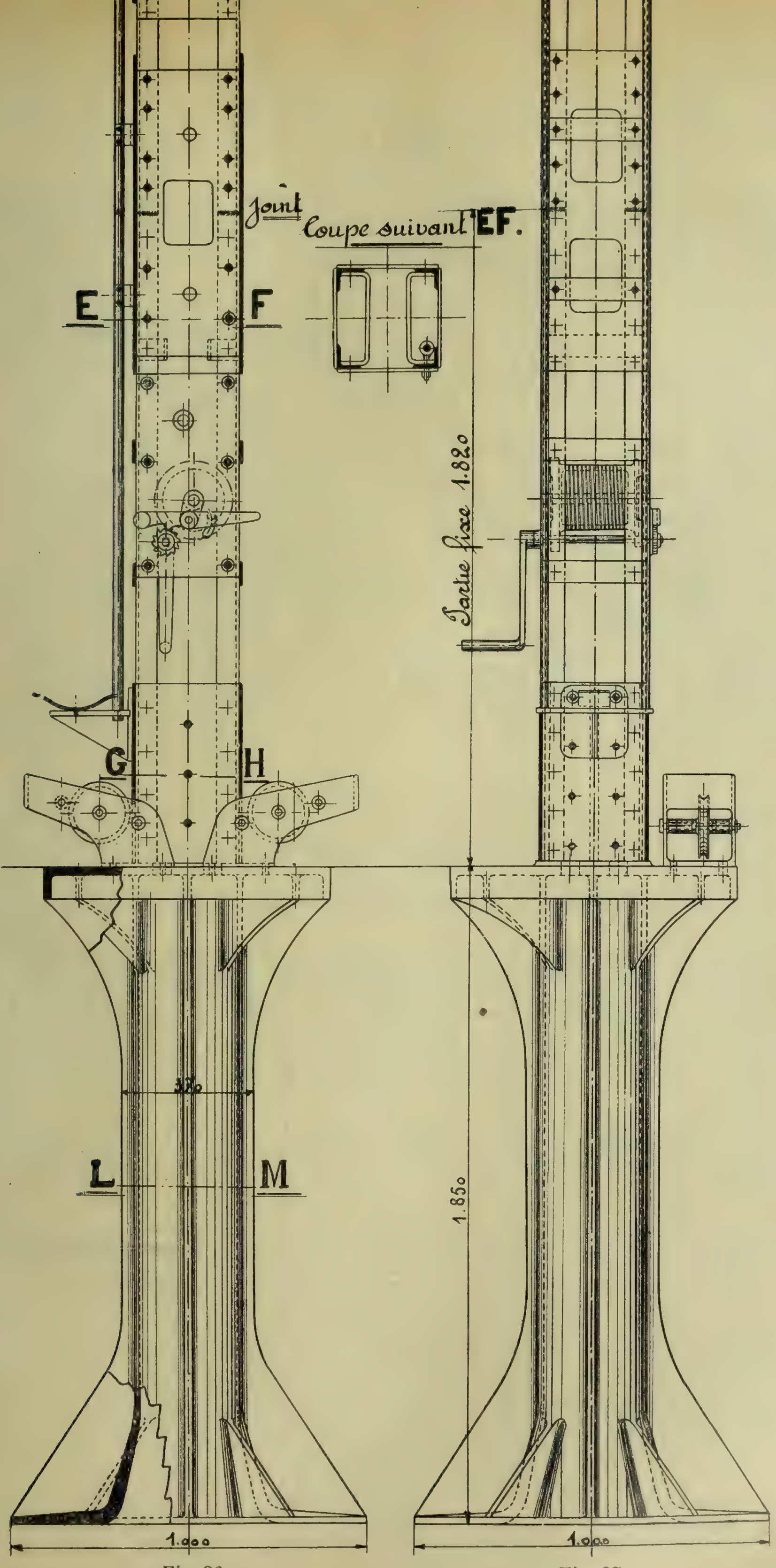
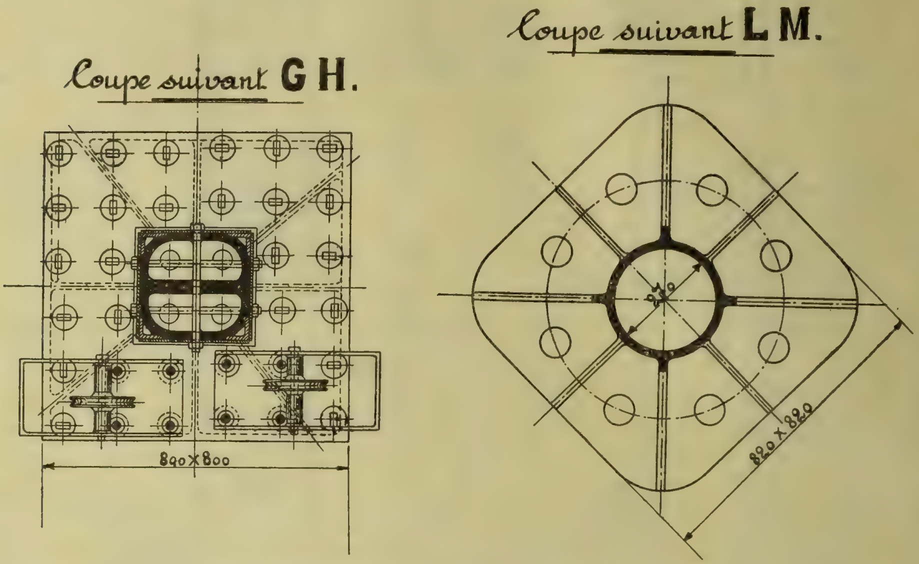


Fig. 36.

Fig 37.

Figs. 36, 37 and 40. — Universal transformable semaphore with superposed arms. Standard base piece. Elevation and section on EF. Scale : $^1/_{20}$.

In cases where the lamps are to be movable, the posts are fitted with retaining pawls (fig. 42) which constrain the lamps to occupy the desired level. The lamps can only be lowered when these pawls are disengaged (¹).



Figs. 38 and 39. — Universal transformable semaphore with superposed arms. Standard base piece. Sections on GH and LM (*sec* Figs. 36 and 37). Scale : $^1/_{20}$.

Explanation of French terms : Coupe suivant GH, LM. = Section on GH, LM.

The withdrawal of the pawls is performed simultaneously from the foot of the post for all the pawls by the same movement which disengages the pawl of the winch.

When the lamplighter requires to raise the lamps, he winds them *a little* too high, he then lifts the ratchet of the winch sufficiently to disengage it, but not to withdraw the retaining pawls; he then lowers the lamps on to the retaining pawls (fig. 36 detail scale $^1/_{20}$).

Figures 50 to 54 show different arrangements of the semaphore posts with one, two or three arms on the left side. These figures also show how the extension pieces can be used.

V. *Standard crownpiece* (figs. 36 and 37). — This openwork crownpiece was selected with a view to obtaining a good appearance without unduly raising the height of the centre of gravity of the semaphore. It was based on the design used by the London & South Western Railway.

(¹) By this arrangement, the lamp is brought truly central with the hole in the arm. In the old semaphores, this centring was not effected.

VI. *Standard arms.* — The arms are made entirely of metal and the axis is central to the width. As they are of the rising pattern, their own weight suffices to set them to danger automatically in case of fracture of any portion of the controlling gear.

A hole 215 millimetres (8 $^{15}/_{32}$ inches) in diameter is cut in the arm central to the width to allow the light from the lantern to show. A second hole is also arranged alongside the first, so as to be available in case the signal is required to show a double light. In the case of a caution signal *placed below a danger signal*, this second hole can be covered by a movable screen which is withdrawn when the upper arm shows line clear (*see* fig. 55).

The semaphore may also be fitted with the shunting arm used at intermediate stations on double tracks worked on the block system; preparation is made for this special fitting. It is shown in figure 56.

This arm is placed at a height of 5·135 metres (16 ft. 10 $^{3}/_{16}$ in.) above the top of the foundation-piece. At night, the position of the arm is shown by a hand lamp which is placed in a special support at the time the siding is used.

The shunting arms are identical with the siding arms and are placed at the same height; they are however lighted at night like the ordinary arms. The backing arms are also fitted at the same height and in the same manner as the ordinary arms.

VII. *Spectacle plates* (figs. 57 and 58). — The spectacle plates for the coloured glasses are shown in figures 57 and 58 and are carried on the lantern brackets. They are operated by the signal arms by mechanism so arranged that they are put to line clear a little after the signal arm, and they return to danger a little in advance of the arm.

In the case of the left hand arm, the spectacle plate is operated by the crank arm terminating in the pin F which engages with the hooked arm G.

In the case of the right hand arm, the movement of the spectacle plate is effected by the crank pin B and the forked arm O.

When the lamps are lowered, the spectacle plates automatically take the danger position.

The vertical travel of the hooked arm G is limited in both directions by a stop pin and by a guide.

VIII. *Operating gear for signal arms.* — In the case of a single arm, the operating gear (*see* figs. 36 and 37) consists of a connecting link, a crank arm with pin, a gab-lever (1) and a bracket with stop.

---

(1) The gab-lever is a part of the gear carried on the semaphore post and is intermediate between the double wire control and the arm to be worked. It is so arranged that the arm can return automatically to danger by the excess of weight in the arm above that in the butt end, in the case of fracture of *either* control wire.

It consists mainly of a straight lever which can turn about a centre pin O on which it rests. The two

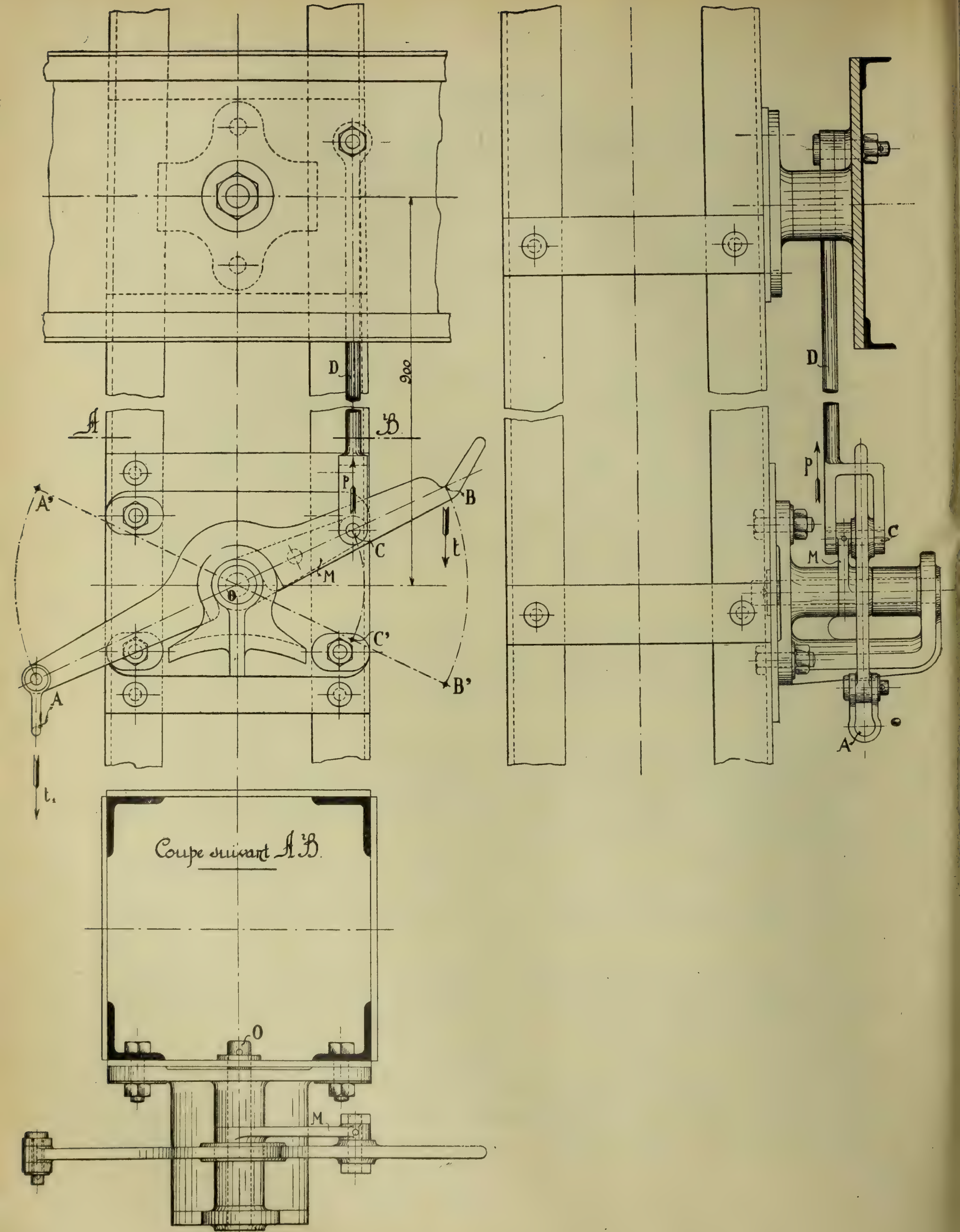


Fig. 36^{bis}. — Scale $^1/_{12}$.

The two ends of the operating wire are attached respectively to the ends of the gab-lever.

If the signal arm is to be operated by a single wire, it is only necessary to prevent the lever from turning on the crank pin; the hole provided in this permits of so fixing it.

To arrange for the double wire control, it is only necessary to do away with the counterweight of the *Saxby balance arm*, and to attach the other end of the control wire to a hole in the tail of the lever which had taken the counterweight.

It is evident that the two ends of the same control must have the same travel.

Where the arms are slotted, the balance arms are not used.

The only method now used is the connecting link with slotted eye. The arrangement employed in the case of simple slotting, is clearly shown in figure 44. That which is employed for double slotting is shown in figure 45.

These figures relate to rising arm signals.

Since the posts are designed to suit all possible combinations, it is always possible to alter a semaphore by removing the existing operating gear and substituting the necessary standard parts which can be obtained out of stock.

IX. *Lamps and their mode of attachment.* — In the case of ordinary semaphores, the usual lamps employed for fixed signals are adopted.

The lamps are oil or gas lighted according to circumstances.

In the case of arms terminating in a V notch and the repeating arms for short block sections, lamps are used with double burners and without glass chimneys.

Both kinds of lamps are carried on identical carriers which are made fixed or movable according to circumstances.

The numbers which supplement the route direction given by the arms of certain semaphores (*see B* below) are lighted by reflected light obtained from lamps with three burners. Either one or two lanterns of this type are required per number signal, according as the figures require to be visible from one side only or on both sides (back and front).

---

ends of the control wires are fastened to it at A and B; the lever carries a pin C which can engage in a notch in a crank arm M which can also turn about O (fig. 36^{bis}); the rod operating the semaphore arm is attached to this crank arm at D and is attached at its other end to the butt end of the semaphore arm.

When the signal is pulled off the gab-lever takes the position A′ O B′, the pin C moving to C′. The lever is acted on by the forces t and t_1 (the tensions on the two control wires) and p (the pull on the signal rod).

Two cases must be provided for :

1° The pulling-off wire (t) may break. The lever in this case turns about O under the action of the forces t_1 and p. The point C′ moves to C and the arm returns by its own weight.

2° The setting-on wire (t_1) may break. The gab-lever under the action of the force t turns upon the pin C and the pulling off wire which is only secured to the hook B by a ring becomes disengaged. The lever is then only acted on by the force p and the arm returns to danger.

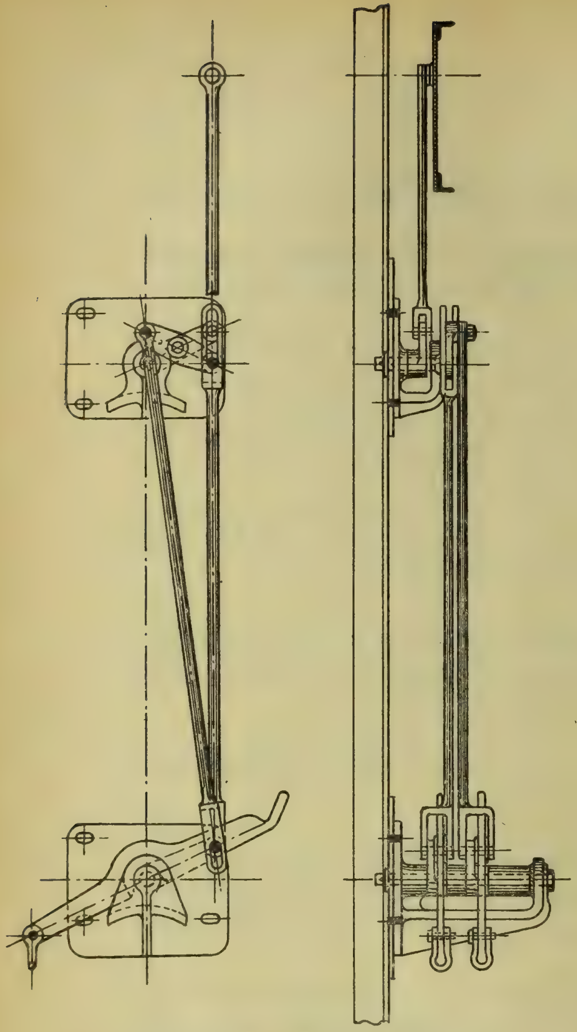


Fig. 44. — Universal transformable semaphore. Control gear for a single slotted arm. Scale : $^1/_{14}$.

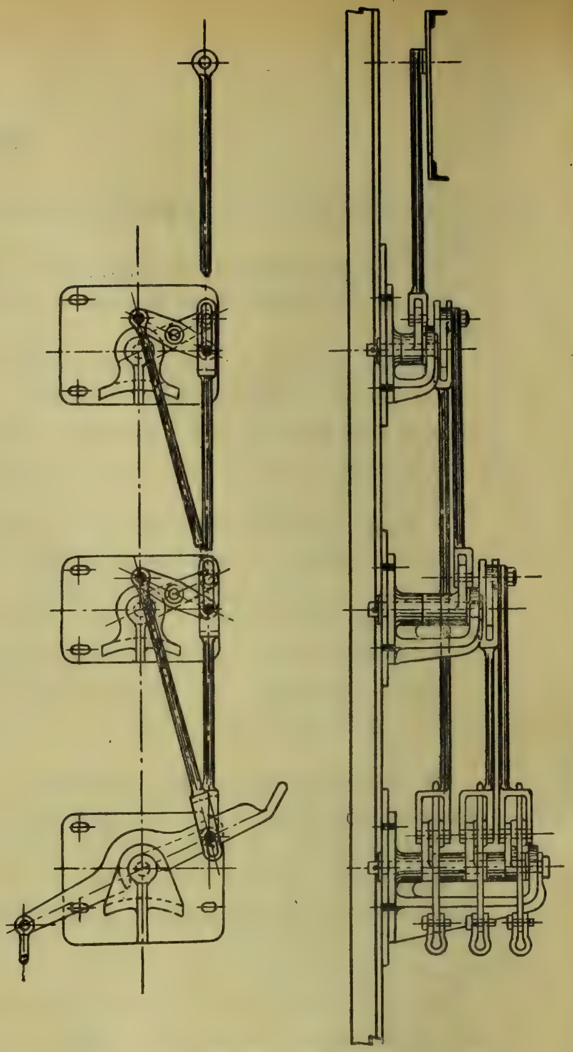
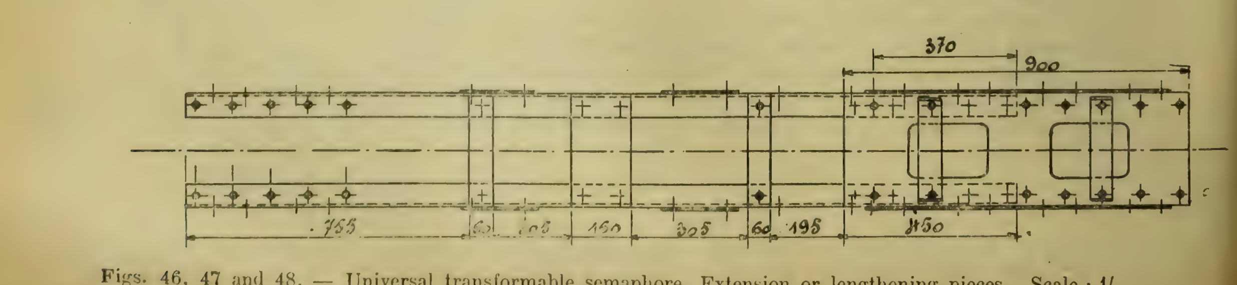


Fig. 45. — Universal transformable semaphore. Control gear for a double slotted arm. Scale : $^1/_{14}$.



Figs. 46, 47 and 48. — Universal transformable semaphore. Extension or lengthening pieces. Scale : $^1/_{20}$.

The lamps are carried on carriers which may be either fixed or movable (*see* figs. 41, 57 and 58) and carry the spectacle plates.

When the carriers are movable, they are fitted with a very strong system of guides as well as a tilting safety catch. They rest when at the top on retaining pawls as explained above.

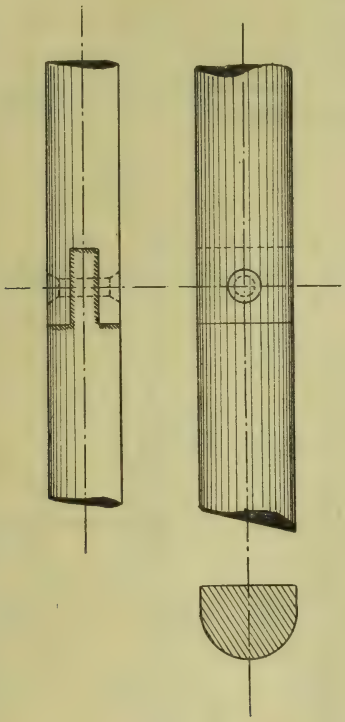
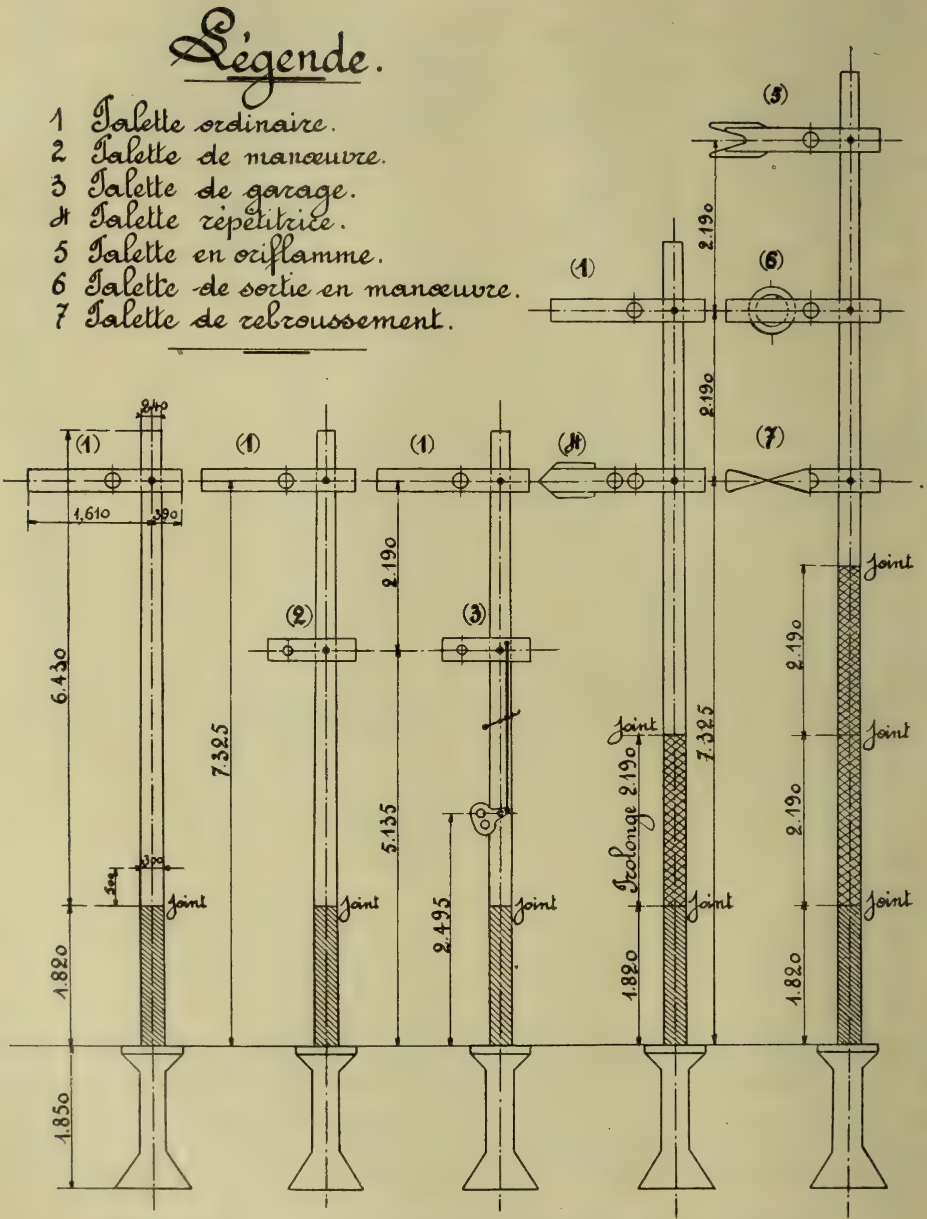


Fig. 49. — Universal transformable semaphore. Joint of guide rods for lamp lowering gear. Scale : $^1/_2$.

When the carriers are fixed, the semaphores are fitted with ladders and suitable platforms. The ladders are made in two lengths, the long lengths correspond to a single arm semaphore; the short arms are of a length equal to the distance between the arms; these form lengthening pieces for the ordinary ladders used in the case of semaphores with several arms. The ladder joints are shown in figure 59.

X. *Names of the component parts of a semaphore.* — The official drawings give the names by which each component part and detail of a semaphore is known. It is therefore always easy to exactly describe any part requiring renewal, and to get together all the parts necessary for a semaphore of any required type.



Figs. 50 to 54. — Universal transformable semaphore with superposed arms.
Examples of different arrangements of standard post and the use of extension or lengthening pieces.
Scale : $^1/_{100}$.

Explanation of French terms : Légende = Description. — Palette ordinaire = Ordinary arm. — Palette de manœuvre = Shunting arm. — Palette de garage = Siding arm. — Palette répétitrice = Repeating (distant) arm. — Palette en oriflamme = V notch arm (main line). — Palette de sortie en manœuvre = Arm for shunting on to main. — Palette de rebroussement = Backing down arm. — Joint = Joint of lengthening piece. — Prolonge = Lengthening piece.

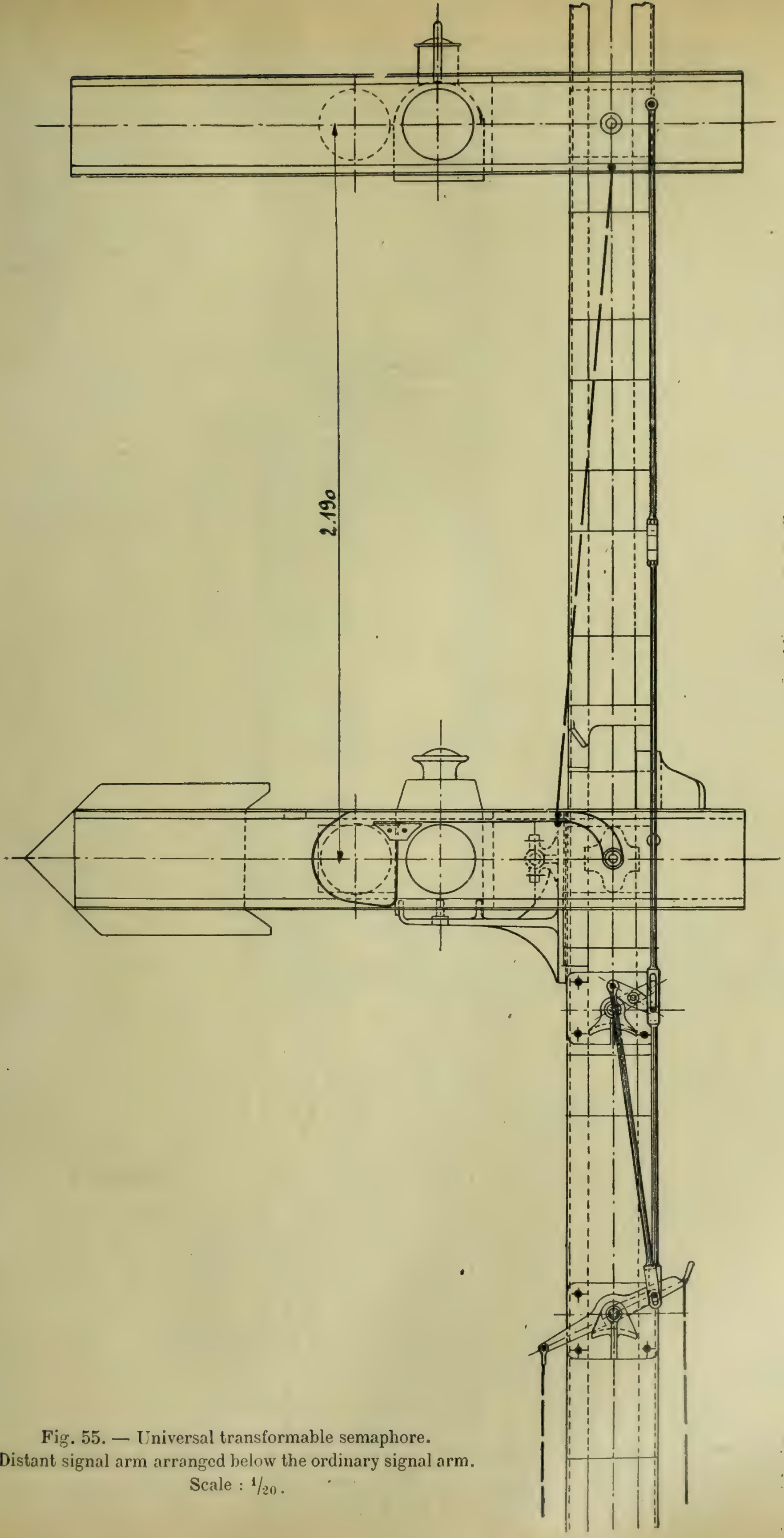


Fig. 55. — Universal transformable semaphore.
Distant signal arm arranged below the ordinary signal arm.
Scale : $^1/_{20}$.

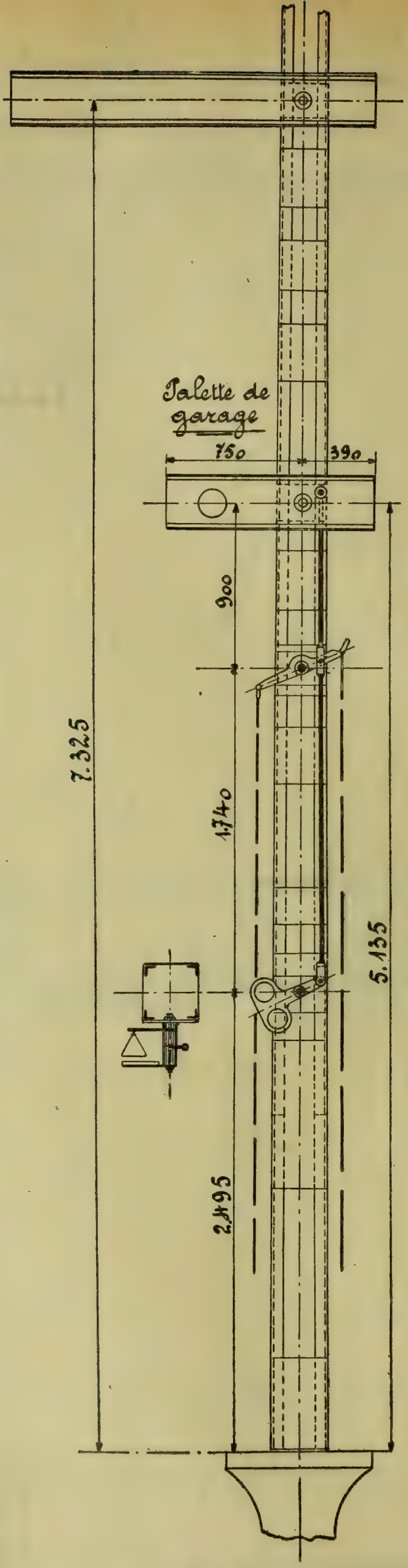
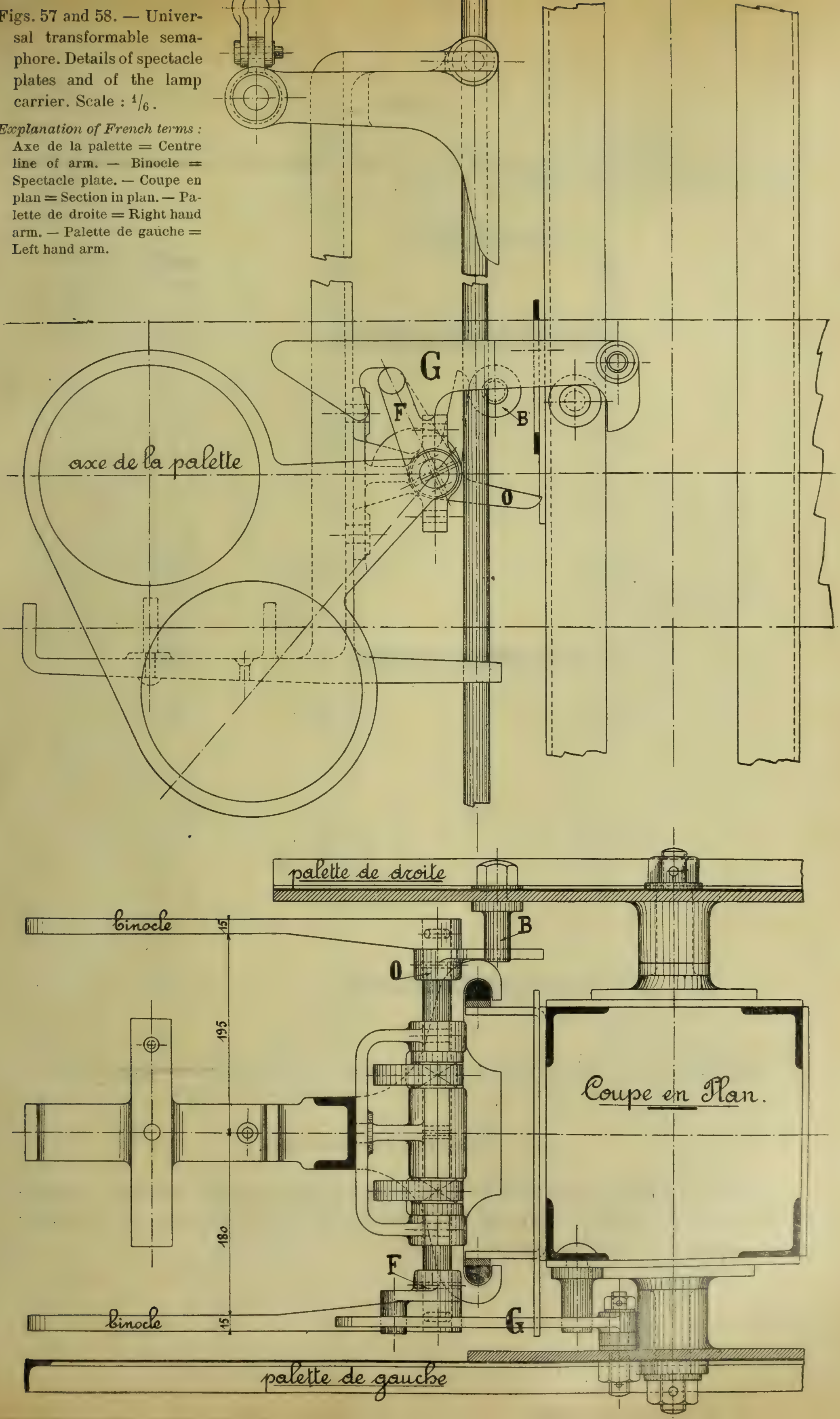


Fig. 56. — Universal transformable semaphore. Siding arm arranged below the ordinary signal arm.
Scale : $^1/_{40}$.

Explanation of French terms : Palette de garage = Siding arm.

Figs. 57 and 58. — Universal transformable semaphore. Details of spectacle plates and of the lamp carrier. Scale : $^1/_6$.

Explanation of French terms : Axe de la palette = Centre line of arm. — Binocle = Spectacle plate. — Coupe en plan = Section in plan. — Palette de droite = Right hand arm. — Palette de gauche = Left hand arm.



All the component parts are practically interchangeable, so that they can always be assembled with the minimum of fitting.

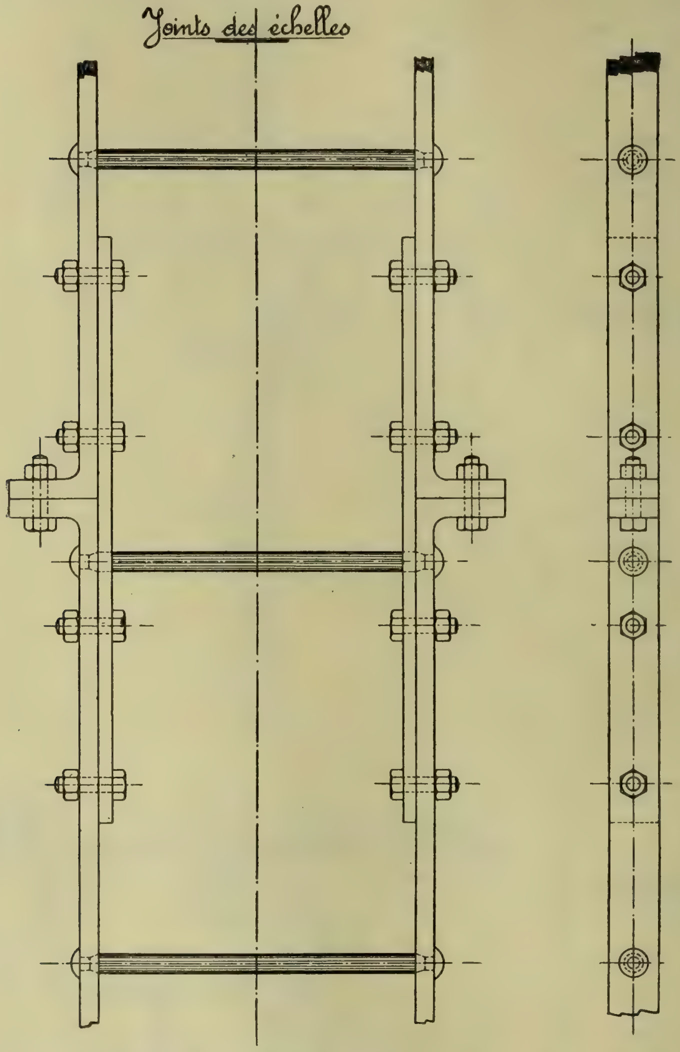
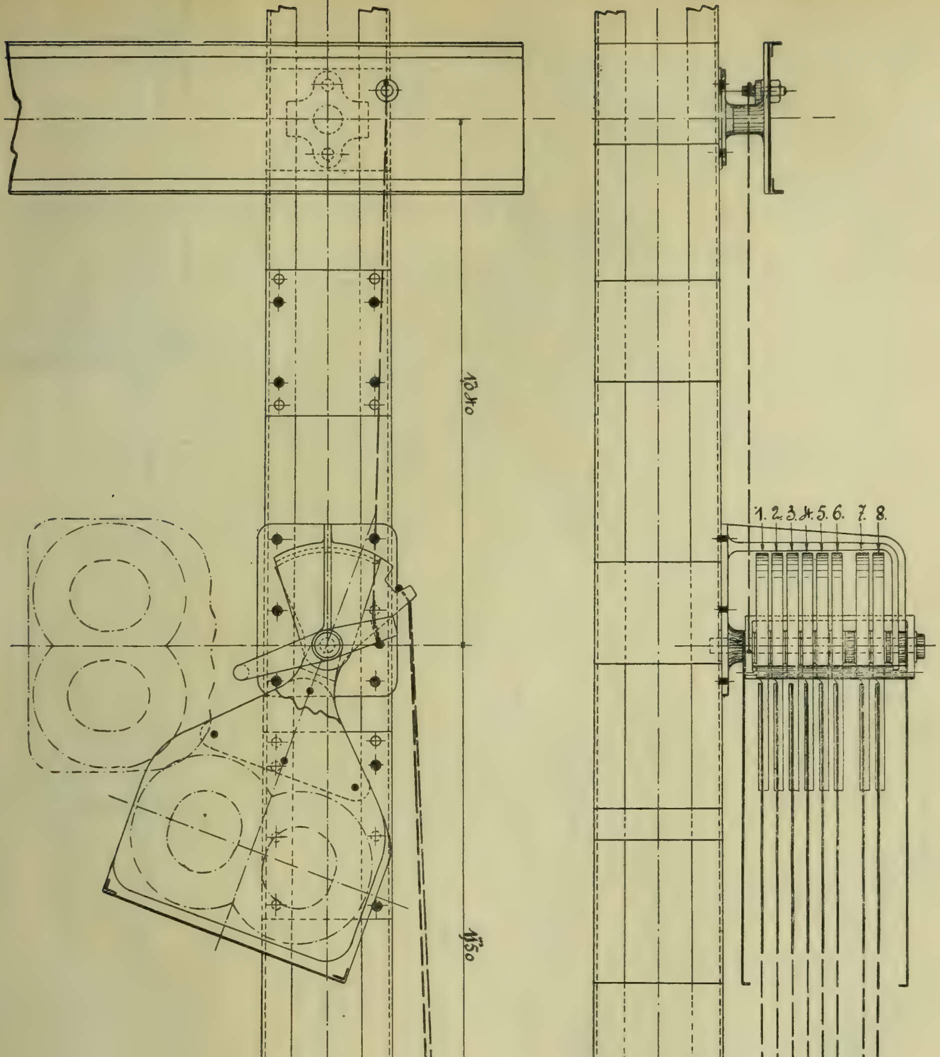


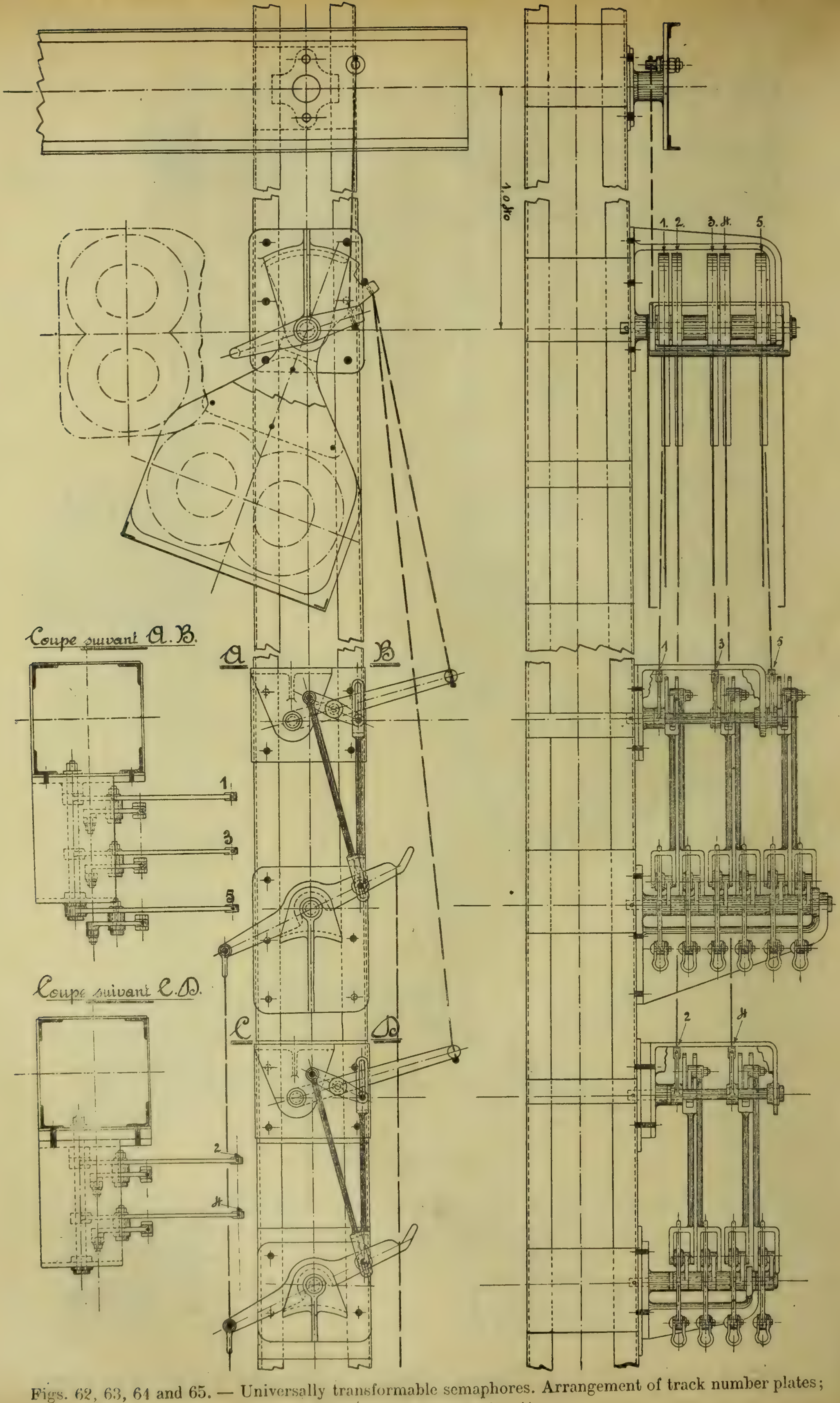
Fig. 59. — Universal transformable semaphore. Method of coupling ladder sections. Scale : $^1/_6$.
Explanation of French terms : Joints des échelles = Ladder joints.

B. — Track number semaphores.

Each of the number plates of an arm, taken by itself, requires the same controlling gear as an ordinary arm, and acts on a stirrup piece common to all the num-



Figs. 60 and 61. — Universally transformable semaphores. Arrangement of track number plates. Eight numbers, not slotted. Scale : $^1/_{15}$.



Figs. 62, 63, 64 and 65. — Universally transformable semaphores. Arrangement of track number plates; five numbers slotted. Scale : $^1/_{15}$.

Explanation of French terms : Coupe suivant AB, etc. = Section on AB, etc.

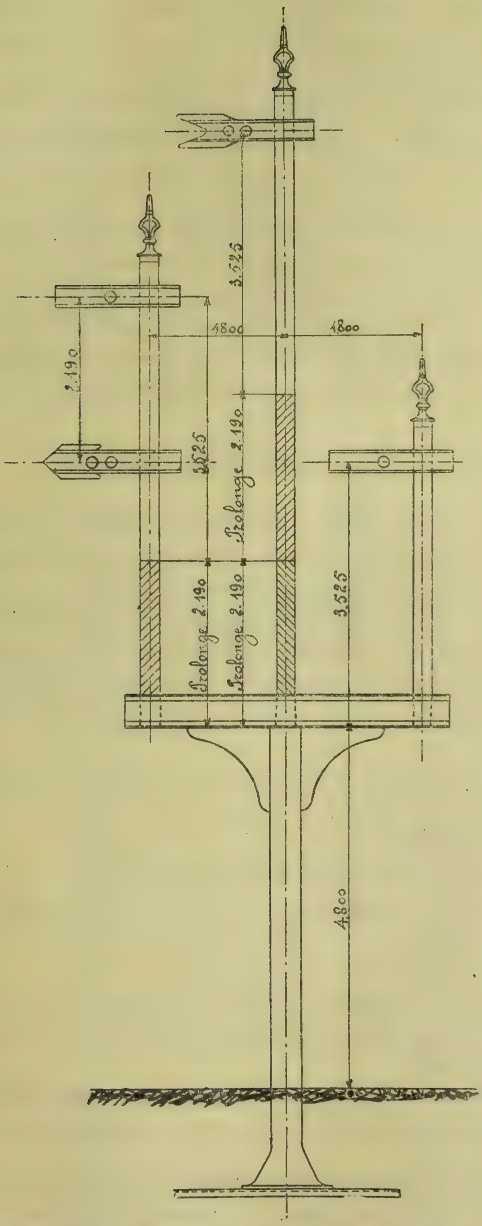


Fig. 66. — Universally transformable candlestick semaphores.
Arrangement of a semaphore with three posts and arms at three heights. Scale : $^1/_{100}$.

Explanation of French term : Prolonge = Lengthening piece.

bers (figs. 60 and 61).. This stirrup piece which is arranged for a maximum of eight numbers, transmits the movement of any one of these to the signal arm.

All the numbers of the same group are mounted on the same horizontal spindle; they are cut out of plate and partially counterbalanced by a tail piece to which the controlling wire is secured. They are painted or enamelled on both sides of the plate.

At night the plates are lighted on both faces by means of a lantern of special type with three burners.

Either one or two of these lamps is used for each number arm according to whether it is necessary to read the signals from one side only or from both sides.

Figures 62 to 65 show five numbers slotted; this is the maximum that can be fitted on a standard type of post, but other combinations are possible. It would even be possible to arrange three non slotted numbers in addition to the five slotted numbers but to do this would require a supplementary bracket.

C. — Candlestick semaphores.

The essential feature in which the candlestick semaphore differs from the ordinary semaphore, consists in the fact that the arms, instead of being placed one over the other, are spread horizontally over a number of posts.

The arm corresponding to the most important track is moreover placed at a higher level than that of the arms relating to the adjacent and less important tracks. In general, each post only carries one arm. The only exceptions to this rule is in the case of the caution arms and the shunting arms which are placed below the main arms.

The arms of the candlestick semaphores are of the same type as those of the ordinary semaphores (V notch, V point, etc.). They are fitted with the same accessories (slots, number plates, etc.).

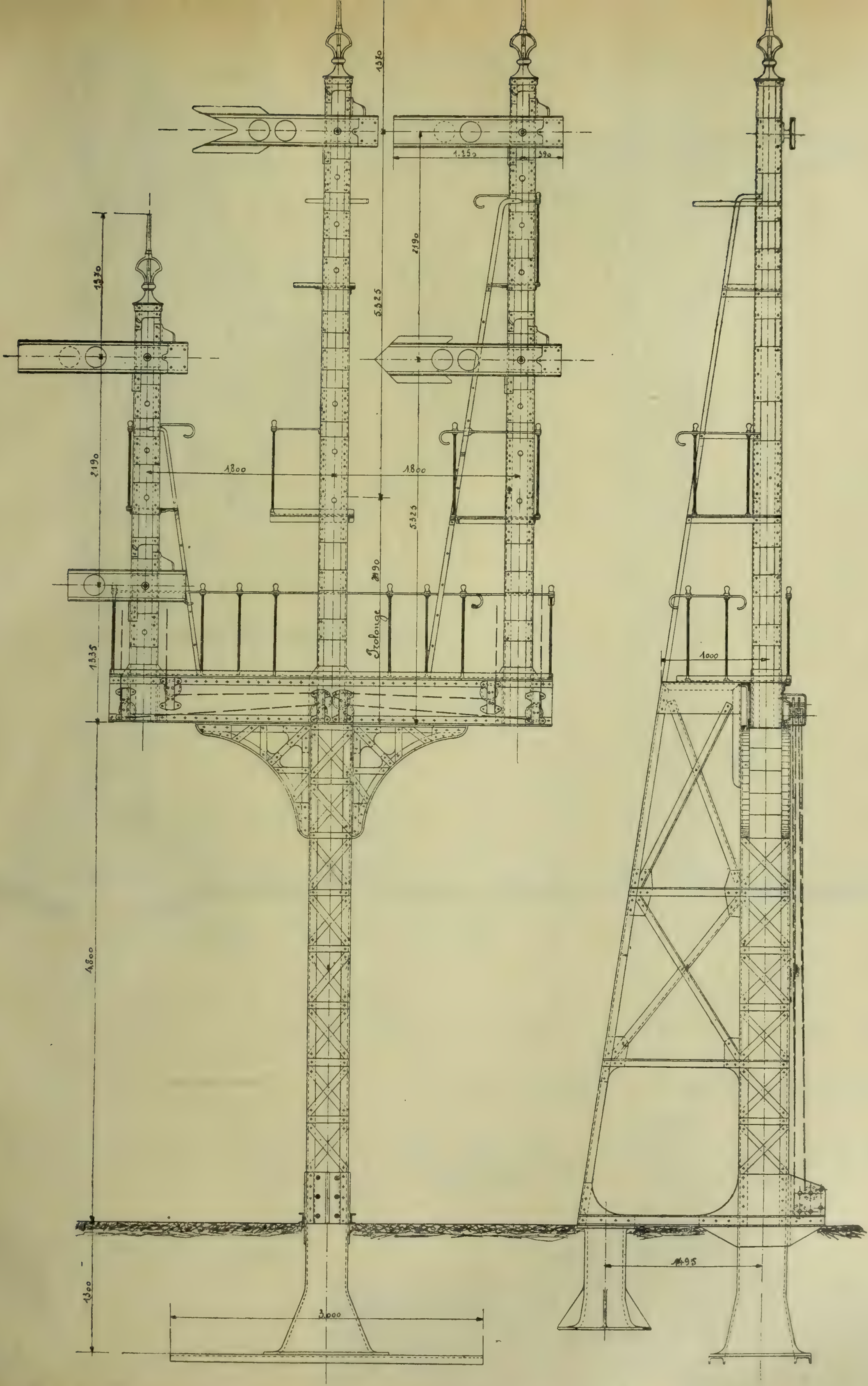
The lamps are of necessity carried on fixed carriers.

The only parts which now require description are the characteristic details of the candlestick type namely : I. — The main (trunk) post; II. — The horizontal crosspiece, and III. — The feet of the posts.

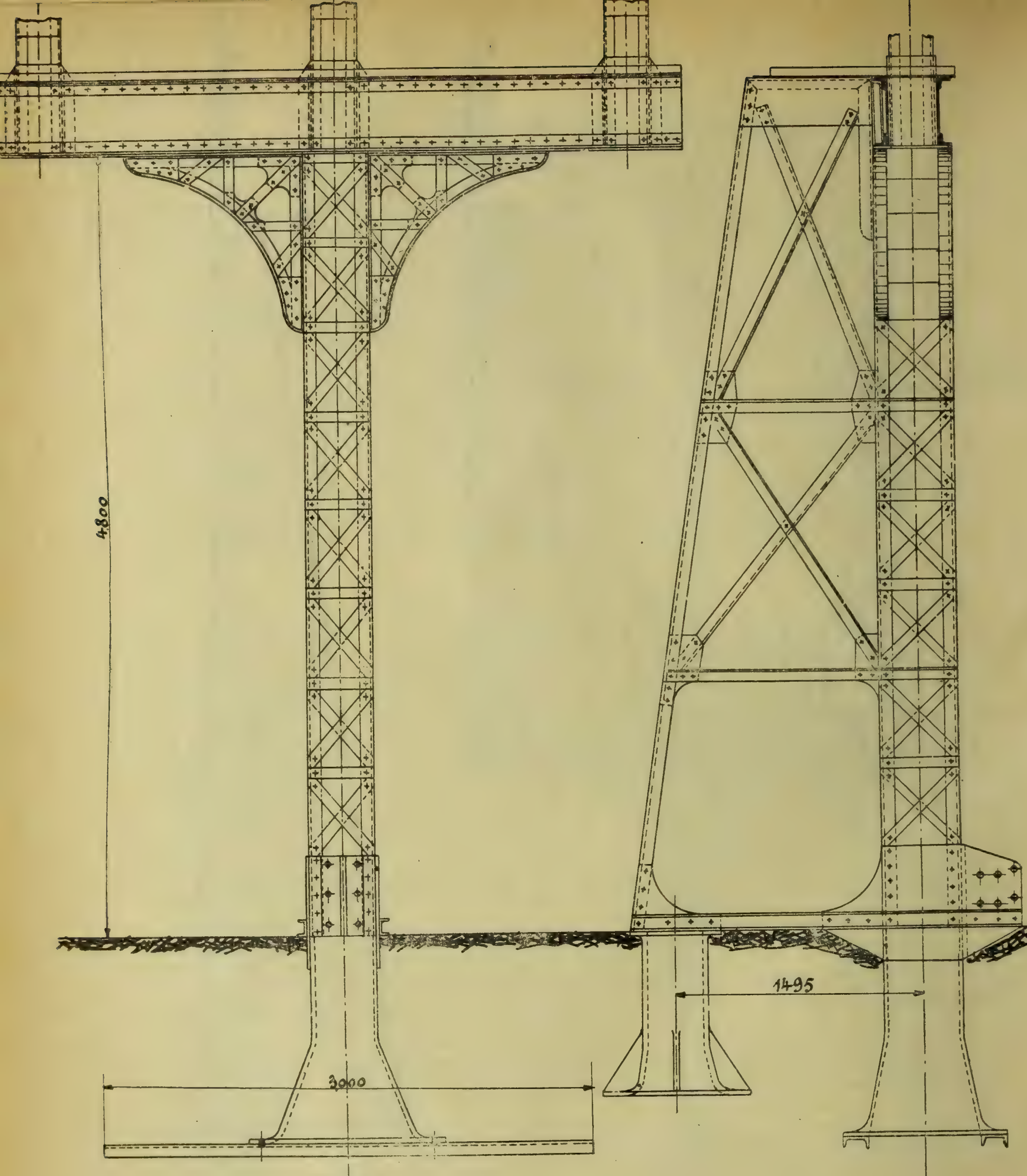
These various details are shown diagrammatically in figure 66, which also shows that the arms may occupy three different heights by making use of the lengthening pieces already described.

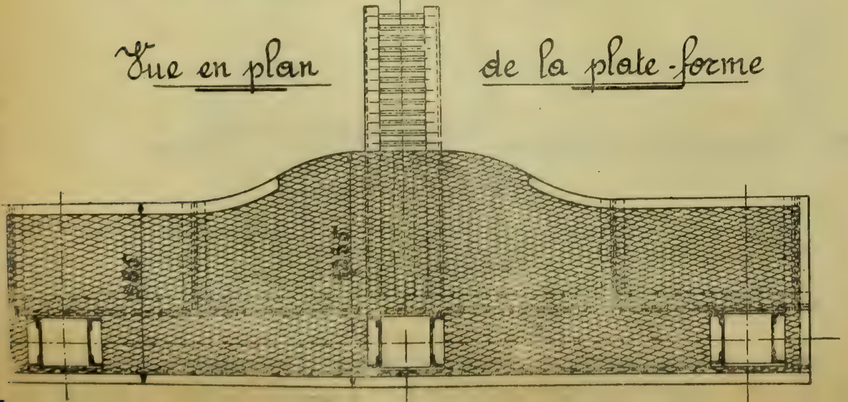
Figures 67 and 68 show a general arrangement, to a scale of $^1/_{60}$, of a candlestick semaphore with three posts, with arms at two heights and with a shunting arm.

I. — *The main (trunk) post* is of rectangular parallel section composed of lattice work and fixed on a cast iron base. It is very rigidly secured to the base of the ladder giving access to the platform, and the base of the ladder is itself furnished with a small cast iron base. This arrangement is intended to give the structure great stability in the direction parallel to the tracks. In order to ensure stability in



Figs. 67 and 68. — Universally transformable candlestick semaphores. General arrangement of a semaphore with three posts and two heights of arms and with a shunting arm. Scale : $^1/_{60}$.

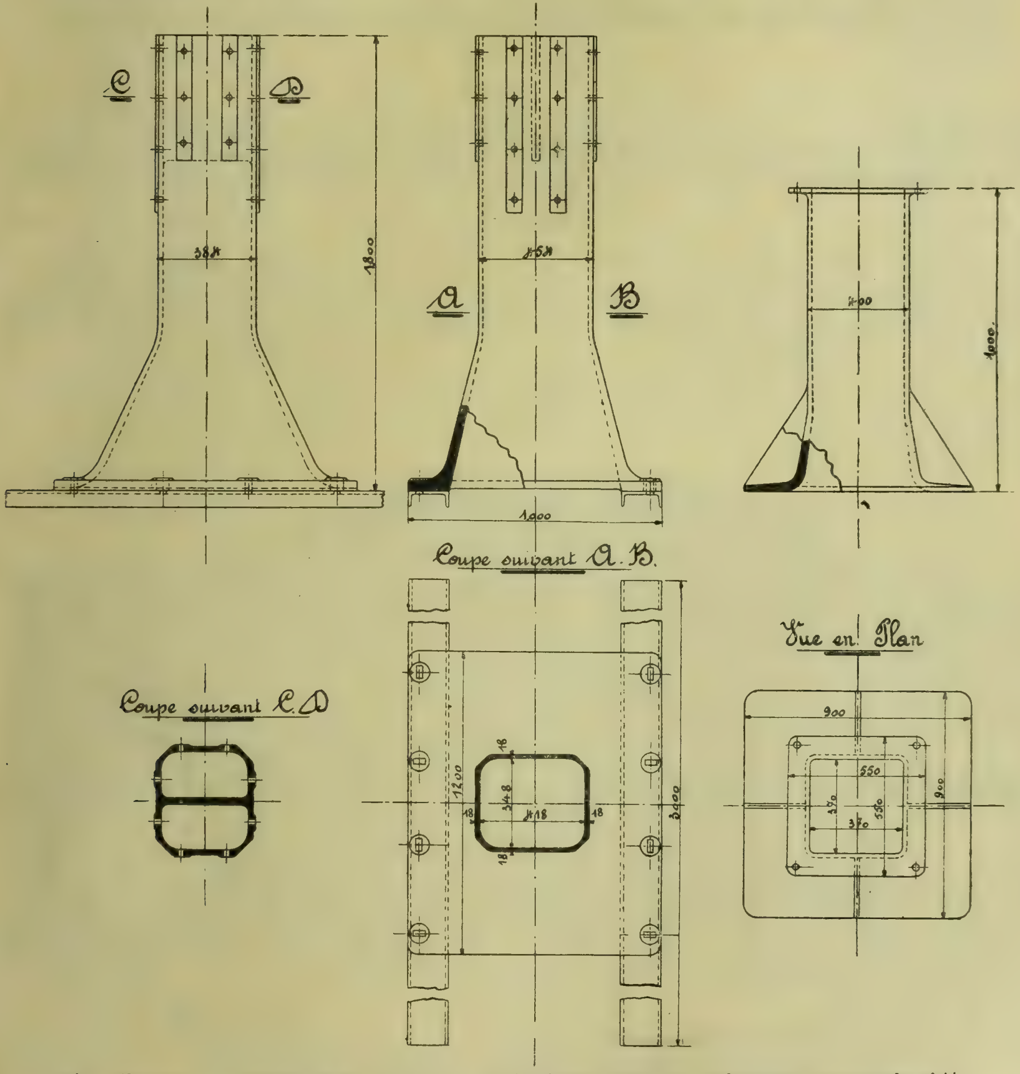



Vue en plan de la plate-forme

Figs. 69 to 71. — Universally transformable candlestick semaphores. Arrangement of main (trunk) post, of horizontal crosspiece and of feet o posts. Scale : $^1/_{40}$.

Explanation of French terms : Vue en plan la plate-forme = Plan of the platform.

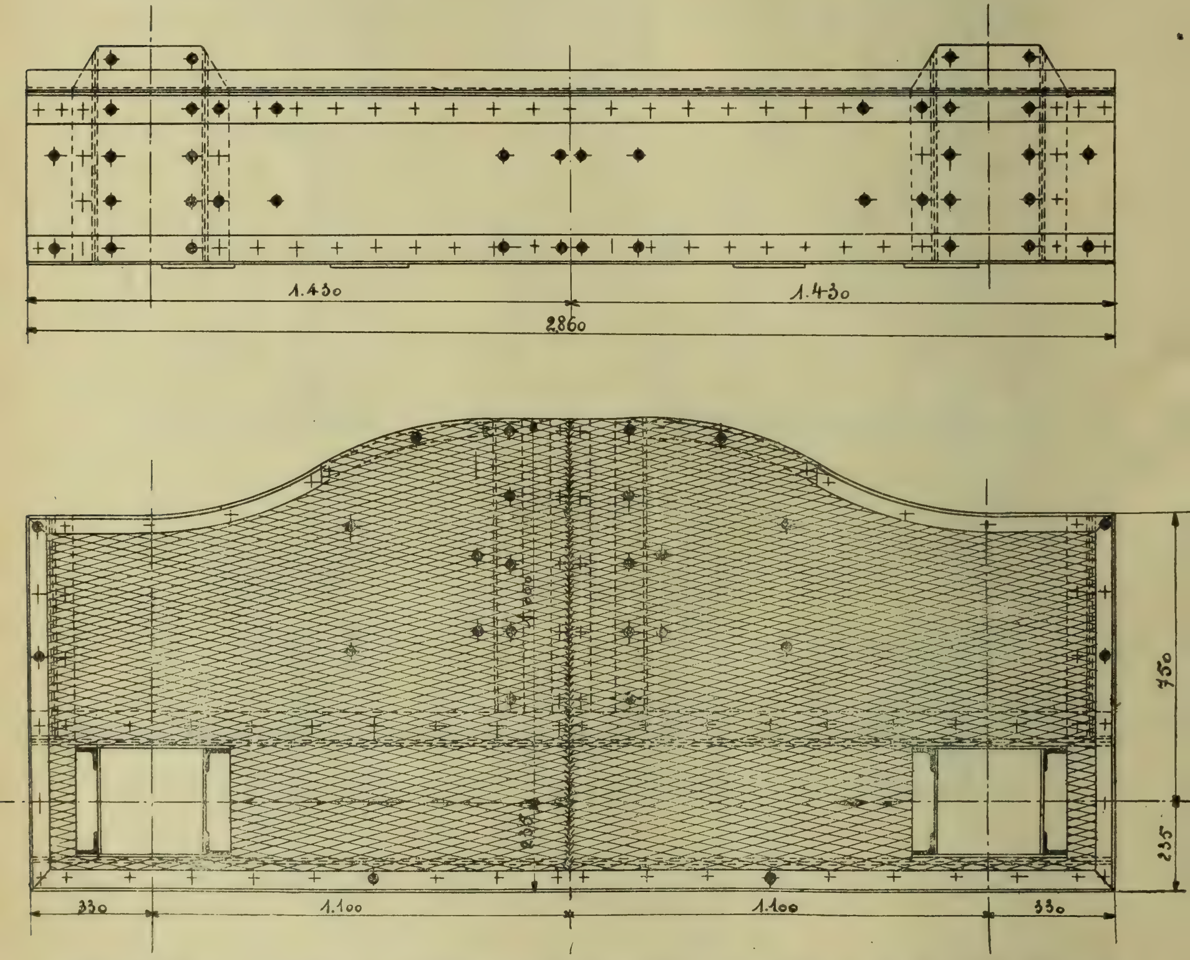
a direction at right angles to the track without necessitating too large a foundation, the larger cast iron base piece is bolted on two inverted channel irons (⊓), each 3 metres (9 ft. 10 in.) long.



Figs. 72 to 77. — Universally transformable candlestick semaphores. Enlargement to a scale of $^1/_{30}$ of the large cast iron base piece of the main (trunk) post and of the small cast iron base for the foot of the ladder.

Explanation of French terms : Coupe suivant AB, etc. = Section on AB, etc. — Vue en plan = Plan.

Where the foundation is hard, these inverted channels (⊓) are merely laid on in the bottom of the trench after this has been levelled up; the hole is then filled in and rammed round the base of the main post. When the nature of the ground is not satisfactory, the two inverted channels (⊓) are placed on a bed of oak sleepers, or better still on a bed of concrete. In the latter case, the cast iron base is filled with cement grouting and the whole of the base piece is embedded in a small block of concrete.



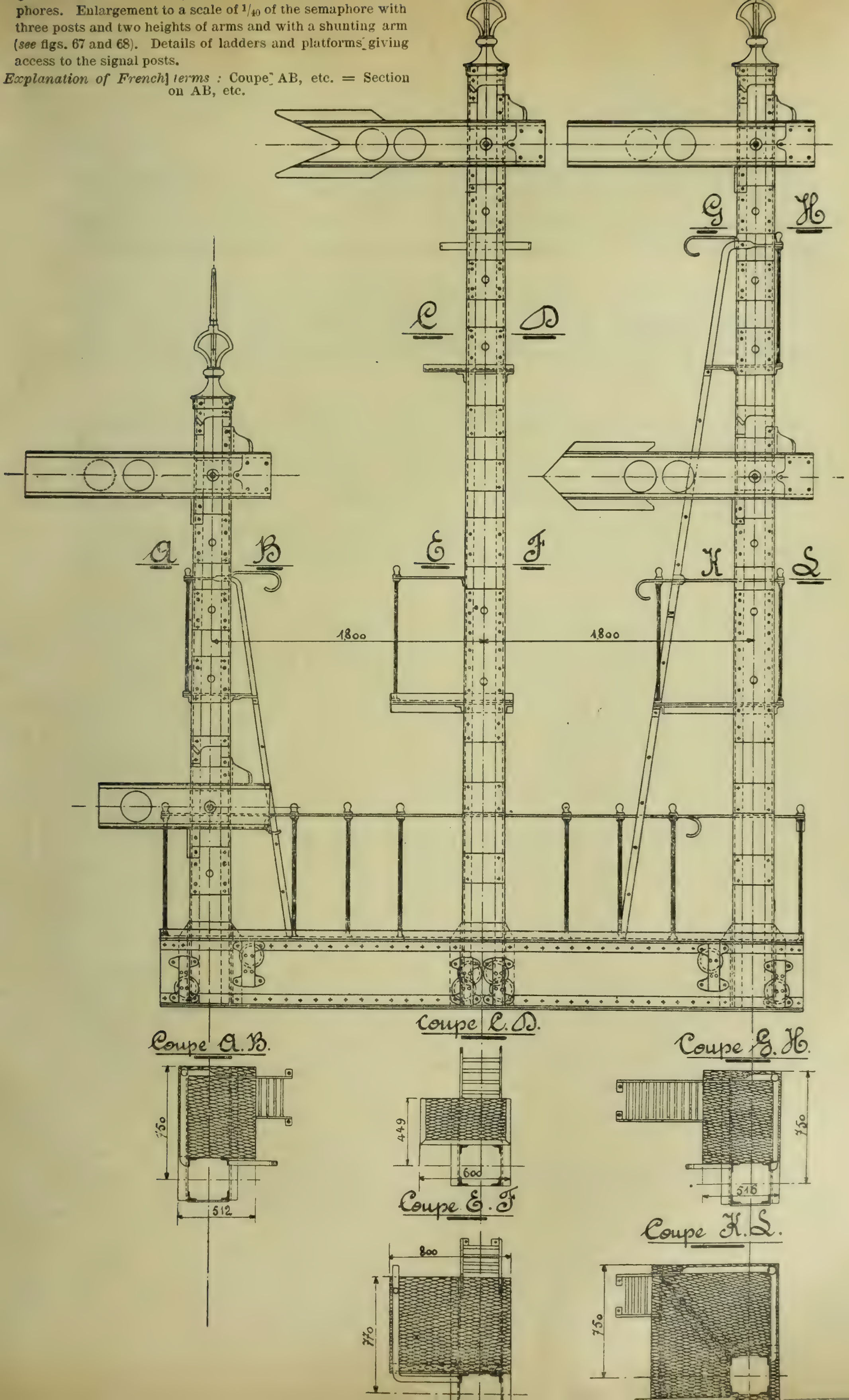
Figs. 78 and 79. — Universally transformable candlestick semaphores. Crosspiece for candlestick semaphore with two posts and platform. Scale : $^1/_{20}$.

Figures 69 to 71 show the general arrangement of the main (trunk) post, of the horizontal crosspiece and of the feet of the posts to a scale of $^1/_{40}$.

Figures 72 to 77 are an enlargement of the large cast iron base of the main (trunk) post and of the small cast iron base for the ladder to a scale of $^1/_{30}$.

phores. Enlargement to a scale of $^{1}/_{40}$ of the semaphore with three posts and two heights of arms and with a shunting arm (*see* figs. 67 and 68). Details of ladders and platforms giving access to the signal posts.

Explanation of French terms : Coupe AB, etc. = Section on AB, etc.



II. — *The horizontal crosspiece.* This is fitted on the top of the main (trunk) post by means of interchangeable brackets and bolts. The crosspiece is of different length according as it is required to carry two or three posts; there are therefore two types, but the mode of fixing on the top of the main (trunk) post is the same in both cases.

Figures 69 to 71 show a crosspiece for a candlestick semaphore with three posts and platform to a scale of $^1/_{40}$.

Figures 78 and 79 show the crosspiece for a candlestick semaphore with two posts and platform to a scale of $^1/_{20}$.

III. — *The foot of each post* fits into a hole made in the horizontal crosspiece. These holes and the feet of the posts are standard so that any of the posts can be interchanged to obtain the various combinations which may be desired.

Figures 69 to 71 show the detail of the arrangement.

Figures 80 to 85, which are an enlargement of figures 67 and 68 to a scale of $^1/_{40}$, moreover show the details of the platforms and ladders giving access to the posts.

[621 .153.2]

ON REPAIRING THE TUBE-PLATES OF LOCOMOTIVE FIRE-BOXES,

By S. RAGNO,
ENGINEER,
INSPECTOR OF THE ITALIAN STATE RAILWAYS.

Figs. 1 to 23, p. 714 to 725.

I. — The advantage of repairing tube-plates.

In 1902, I announced the first results (1) of some trials of the system of repairing the copper tube-plates of locomotive fire-boxes by means of pieces of thin copper sheet, forming true cover plates or patches secured by plain ferrules also made of thin copper. I was then the chief of the locomotive department of the former Italian Mediterranean Railway Company, at Naples, and in my note I stated that " the almost fortunate shortness of locomotive stock (2) had led me to examine and investigate how to keep the locomotives in working condition as long as possible. "

Several of my colleagues in Italy, who read my paper, thought the system was already known, as they mixed it up with another system of repairing tube-plates by means of pieces of thick sheet, secured by threaded ferrules, or otherwise.

I induced other locomotive sheds and shops to try the system described, so that its ingenuity and usefulness became gradually recognized.

Mr. Toppia, the locomotive superintendent of the second section of the old Mediterranean Company, applied to me for special skilled men to teach the men at the Alexandria sheds, and obtained very satisfactory results. He wrote to the General Management that " considering the deplorable lack of locomotives in the second half of last year, 1903, it was a very great advantage to us to be able to continue to use a good many locomotives which would have had to be sent to the main shops, to have new tube-plates put in, had it not been possible to repair them at the sheds according to the Ragno system. "

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(1) *Rivista Strade Ferrate,* No. 20, second year, Milan.

(2) Owing to great traffic increase, I had during five years to operate a service with 104 to 110 locomotives, for which 112 to 120 locomotives had previously been used; soon after this was increased to 125, while the service was reduced.

One who was opposed to my system informed me that it could only be adopted except under special circumstances, particularly if stock was short, but that as soon as enough stock was available, it was not altogether acceptable.

In 1905, I published, by order of my General Management (that of the old Mediterranean Company), a second note in which I maintained that the numerous trials made in Italy justified the general adoption of the system (¹).

I will now proceed to prove this.

It may at once be remarked that it would be wrong to assume the system concerned to be an unwise economy in locomotive maintenance; on the contrary, it has enabled me to operate a heavy service without inconvenience, for years, simply by doing away with the very ill-understood system of renewal of parts. In maintaining rolling stock generally, and especially in the case of locomotives, very radical measures must be taken if disagreeable surprises are to be avoided.

During the last year and a half I have lived in Belgium, in France, in England, and a little in Germany, and I have observed how, as a rule, this principle is acted on thoroughly.

But unfortunately the principle is not always well understood in Italy. It is true that for many years other reasons have been given for our maintenance not being quite satisfactory in some cases, but this is not the place for that question, and I will not discuss it.

Now just as the fire-box is the weakest point in a locomotive, so is the tube-plate the weakest point in the fire-box; hence the great importance of any investigations having as object increasing the life of the tube-plate as much as possible.

Practical experience shows that it often happens that new tube-plates, after being in use for two years (in many cases even less), become so worn that they can no longer be used.

It follows that it should be one of the chief objects of the locomotive engineer to find methods for less frequently replacing tube-plates and consequently for less frequently sending the locomotives to the main repairing shops.

Even if any defects in the tube-plates are not quite apparent, they are none the less objectionable, even if we do not consider the important fact that the locomotive staff can use their existence as a pretext to justify many things.

Now if a tube-plate is to be replaced, it is clear that the locomotive must be sent to the main shops. It is probable that in such a case the locomotive would be overhauled generally, or at least the renewal of the brasses, the wheels and the rods would be considered, and the general adjustment of the engine, etc.; general overhauls would thus have to take place at short intervals, unless the locomotives with defective tube-plates were used for some time for subsidiary services.

(¹) This note together with a tube-plate which had been repaired and had been in use for a further term of two years, was shown by the General Management of the Italian State Railways at the last Milan Exhibition. It was awarded a diploma of honour.

If no attempts be made to repair tube-plates, however certain their success, one comes into conflict with that indisputable axiom of traction practice, that every possible means must be tried at the loco sheds before sending the locomotive to the main shops.

On the other hand, if we accept the principle of repairing a tube-plate at the small shops which are at the sheds, any smaller adjustments required may be attended to at the same time, without interfering with the bearings, etc., still in working condition; this is not the practice at the main shops. There the repairs should be thorough and minute, so as to make the locomotives practically equal to new; there should accordingly be as long an interval as possible between such repairs.

It must be remembered that most cases of general overhaul arise from the need of replacing tube-plates, and that such general overhaul in the main shops takes on the average four to seven months in favourable cases; sometimes the stay at the main shops lasts ten months or even more; that is true of nearly every country.

It is therefore a problem of interest to railway engineers to discover a means for repairing tube-plates, damaged as regards some of the interspaces between the tube holes, without keeping the locomotive idle for longer than from ten to twenty days, at an expense of 300 to 400 francs (£12 to £16), general expenses included, and to use the locomotive for its regular work for at least two years longer, without sending it to the main shops for a general overhaul (1).

The cost of the maintenance of the rolling stock forms a considerable percentage of the total working expenses of railways. Every possible method for reducing this cost should be examined and applied.

I might here mention the Italian locomotives, working at pressures up to 14 kilograms per square centimetre (199 lb. per square inch), used either for heavy goods service or for fast trains (under much less favourable conditions than exist in central Europe), which had their tube-plates repaired according to my system.

In the case of some of these locomotives, thin sheet secured by 80 to 90 ferrules had to be used; nevertheless they mostly were kept working for two years more.

The life of a repaired plate also depends on the care with which it has been repaired, and (what is of even greater importance in the case of new plates) on the skill with which the locomotive is fired and on the attention of the crew; and finally on whether pooling is adopted.

When this system of repairing plates is adopted, the fitting work done at the sheds should not increase; during my management of the Naples sheds, after two years during which I applied the system on a large scale, I was enabled to reduce the number of hands as fewer plates failed and fewer defects were observed on the road.

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(1) I showed at the time when my first trials were made, that the number of locomotives sent to the main shops for general overhaul was reduced by 7 to 8 per cent, when my system of repairing tube-plates was adopted.

If we compare the expense incurred by sending a locomotive to the main shops, for instance once every four years (this is a very favourable average), and the expense of keeping it at the sheds and sending it to the main shops only once every five or six years, we at once see what an economy can be effected in the general expenditure on maintenance, and that without taking into consideration the standing idle of the locomotive, the saving in material already mentioned and the inconvenience to the service.

It is useless to give the figures, as the argument is self-evident and the opinions propounded are completely justified. Of course, there is a limit to everything; consequently as the system is recognized useful, it must be applied rationally, particularly at the sheds, and at the main shops on suitable cases of tube-plates which begin to show signs of damage.

Nearly all countries are at present suffering from shortness of locomotive stock. The heavy work locomotives have to do, the changes in the staff, the quality of the copper, and more particularly the use of electrolytic copper (1) result in frequent cracks in the interspaces between the tubes; it is therefore clear that any easy and practical method of repairing such damage should be of great advantage.

⁂

In my second note, I discussed the attempted autogenous soldering of cracked tube-plates.

In a work just appearing in Italy (2), I have explained why although it is possible to join large pieces of copper by the oxyhydrogen or oxyacetylene blowpipe, this method is not applicable to the tube-plates of locomotives.

The copper conducts the heat so well that it is impossible to heat the part of the tube-plate to be joined properly, even if two powerful oxyhydrogen or oxyacetylene blowpipes are used. Electric welding is, as a rule, not suitable for copper; therefore as already stated we have to use thin sheet.

All the work dealing in detail with the boilers of locomotives, as a rule, consider the ordinary methods of construction or the well-known rules for repairing the different effects produced by surface or angle corrosion in the different parts of the boiler : corrosion of projecting screws and rivets, application of patches to damaged walls, and other similar and miscellaneous cases which occur more or less in all boilers (3).

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(1) At present it is no longer used for plates and stays, and arsenical copper is beginning to be specified, and with reason; it seems to give better results as suboxide is absent.

(2) *Saldatura autogena dei metalli*, Hœpli, Milan, 1907.

(3) Richard : *La chaudière locomotive et son outillage* (Paris, E. Dumons, 1886). — The Austrian Ingenieur und Architekten Verein in : *Défauts des chaudières des locomotives et des locomobiles* (Paris, Baudry & Cie, 1895). — Keromnès : « Note sur l'entretien et la réparation des chaudières des locomotives dans les ateliers du Chemin de fer du Nord » (*Revue générale des chemins de fer*, vol. XV,

The *Bulletin of the Railway Congress* (No. 9, September, 1903) refers to my paper and says :

" In a note published in 1892 on the maintenance of locomotives on the French " Northern Railway, Mr. Keromnès stated that ' when a copper tube-plate shows " fractures between the tube holes, the only thing to do is to put in a new tube-" plate '. This dictum practically expressed the opinion of railway engineers at " that time, but since then attempts have been made, in repairing shops, to " improve the methods for repairing plates, and the author is one of those who " have done most work in this direction.

" He gives us, in this interesting pamphlet, an account of the results obtained.

" The pamphlet is all the more valuable for specialists because it gives the results " of experiments made by a practical man and described by himself. "

Finally, it may be stated that as regards maintenance of rolling stock, instructions should be given by engineers who have always been practically engaged in it.

Much of what has been written about repairing fire-boxes is too theoretical, and the opinions of theorists on the subject often result in serious trouble difficult to check.

The practice of locomotive engineers in different countries is determined by the state of the rolling stock, even if it is of antiquated type and there is not enough of it.

Theory and theoretical investigation are not to be despised, but in questions of this kind practice outweighs everything.

II. — Methods formerly used.

It has several times been attempted to repair tube-plates, which had cracked in the interspaces between the tube holes, by means of true cover plates or patches consisting of thick copper plate.

Attempts were first made to use two pieces of copper, a little thinner than the tube-plate, one on the fire side and the other on the barrel side, so as to form a true double strapped joint; or else a single patch was placed on the one or the other side.

The pieces of copper were generally held in place in these three cases by means of threaded ferrules, beaded over at each end (fig. 1).

The thickness of the patches at first used was at least 10 to 15 millimetres ($^{25}/_{64}$ to $^{19}/_{32}$ inch); only rarely was it reduced to 8 millimetres ($^{5}/_{16}$ inch), for the intention was that the copper was to act as a substitute for the broken part of the plate and restore its strength.

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part 1, 1892). — Desgeans : « Chaudières de locomotives, corrosions, cassures et fissures de toute nature » (*Revue générale des chemins de fer*, vol. XXII, part 2, 1899). — Pietro Verole : *Note sur les réparations économiques des chaudières de locomotives* (Milan, typ. et lit. Ing., 1894-1895).

The results were nearly always rather unsatisfactory, and even entirely so in the case of the patches applied on the fire side, for these became burnt. The unfavourable opinion, generally expressed, of these joints thus seemed justified, and it also seemed correct to say that when a plate had cracks the best thing to do was to put a new one in. The screwed ferrule work was of itself very expensive, so that taking into consideration that the method of repair described generally gave bad results, it was assumed that there was no advantage in repairing the plates.

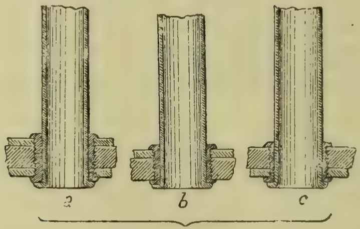

Fig. 1.

This method of repairing plates became less and less favoured and more limited and was applied when cracks extended over a few interspaces only; especially in the case of new locomotives or locomotives very recently subjected to general overhaul, in order to avoid having to send them to the main shops.

In the course of my experiments, I have not omitted to try the methods and systems proposed by other engineers and authors. I merely mention the chief here in order to show that they were all tried, but I may at once add that taking them altogether, they never gave very striking results.

⁂

In the case of a plate with but few cracks in the interspaces and with the cracks not extending right through, if the tubes near the damaged place are in good condition, attempts are made to close the cracks by expanding the tube ends and forcing the bead against the cracks. If the tubes are worn and burnt out at the beads, it is recommended to replace those next to the cracks and bead them over well, so that the beads touch and cover the said cracks (fig. 2).

This method may prove useful when the few cracks are just beginning to form and the tubes are still in a excellent condition so that they can continue to be used before their renewal and the repair of the tube-plates are undertaken.

⁂

Mr. Keromnès, like other authors, recommends that in the case of limited cracks which have already been protected by means of tubes with large beads, small cap screws should be used, screwed into holes drilled into the damaged part and tapped (fig. 3).

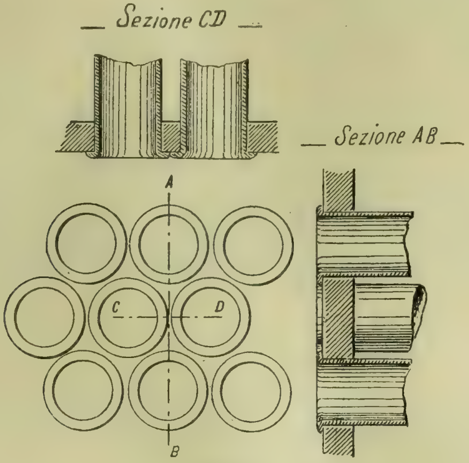

Fig. 2.

Explanation of Italian terms : Sezione = Section.

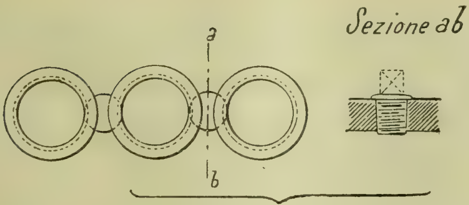

Fig. 3.

In order to tap these holes properly, it is necessary to plug the holes of the neighbouring tubes, provisionally, by means of white metal afterwards removed.

I have tried this system and the results were only fairly satisfactory. The two locomotives on which it was tried, had to be sent a short time after to the main shops to have new tube-plates put in; the locomotives could only be used for a very short time for subsidiary services.

⁂

In the case of another cracked plate, another method was adopted. In the first place, the holes between the damaged walls were plugged by screwed copper plugs and subsequently, smaller threaded plugs were put into the damaged part (fig. 4).

The result was also not more satisfactory; after only two months the locomotive so repaired had to be sent to the main shops.

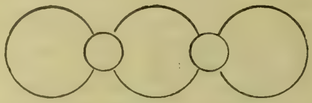

Fig. 4.

The use of plugs of this kind is advisable in the case of locomotives which will anyhow very soon have to be sent to the shops, and when there are a few damaged interspaces and it is intended to use the locomotive a few months more for shunting or yard work.

⁂

It is also intelligible that it is very injurious to flatten out any bulging such as often occurs (particularly in the lower portion), by means of blows given with a copper hammer or by pressure produced by screws.

Although such bulged places may not look well, it is nevertheless advisable, when the tubes are replaced, not to subject the deformed part to other injurious strain or deformation.

By using tubes of different length, the bulged part may be fitted perfectly when the tubes are being replaced.

Another unsatisfactory method is also proposed by Mr. Keromnès for rounding the oval holes produced in tube-plates by deformation. He proposes that a large number of drifts should be placed in two or more adjacent horizontal rows of holes, and then hammered, at first gently and then more strongly, starting at the top and finishing at the bottom. He proposes to produce thus a kind of drawing down of the plate so as to true the oval holes in the upper part. Finally, as the plate bulges towards the barrel, it would have to be straightened by screws forcing it in the fire-box direction.

Not many arguments are necessary to show that this system is bad; all the perforated part of the plate being surrounded by a solid mass, stronger and less easily deformed, is subjected to enormous strain, and must necessarily be affected very injuriously.

III. — The reason for using thin sheet. — Instances. — Application.

The excellent results obtained when the system I have proposed for repairing tube-plates which are to some extent cracked is applied, are chiefly due to the fact that thin sheet is taken for patching. I will now give the reasons which make it advisable to use such sheet.

It might be objected that the use of such very thin sheet would result in a loss of strength corresponding to the damage in the interspaces of the plate. In this connection we may mention that the perforated part of the plate, being supported by the tubes, is only subjected to very small stresses produced by the internal pressure of the boiler.

The triangular interspaces between three adjacent holes (fig. 5) being supported on the three sides by the tube beads on the fire-box side, can be considered very nearly as the bottoms of small prismatic vessels; consequently, it is in the central parts of these surfaces that the greatest stresses are produced by the internal pressure of the boiler, and where consequently the maximum strain results. Now it is just in the central parts of these triangular interspaces of the tube plates, that cracks never occur.

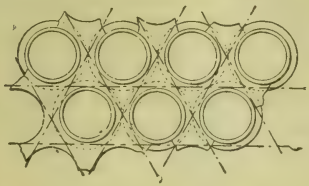

Fig. 5.

This would lead to the deduction that the formation of cracks in the interspaces is not due to want of resistance to the internal pressure of the boiler, but on the contrary, to quite a different cause.

On the other hand, it might be argued that if the triangular interspaces are considered as the bottoms of prismatic vessels, the sides would be subjected to greater stress, for they form the connection between one base and the next adjacent base.

Before answering this, I would remark here, and that for the first time, that when the plates have vertical rows (the most rational arrangement of the holes), it is always observed that the cracks, whether many or few, are always produced in the zone of interspaces included between the first and the third row, laterally and to the bottom, as shown in figure 6 by the two lines *mm* and *nn*.

In the case of tube-plates with horizontal rows (an arrangement to be condemned), the cracks are always at first formed at the bottom, and then in some cases also at the top, as shown in figure 7 by the lines *mm*, *nn*, *oo* and *pp*.

This observation of where the cracks form, at once shows that they are chiefly due to temporary movements of expansion and contraction of the perforated part considered as a whole, and not to want of strength of the interspaces considered separately; otherwise, the cracks would be distributed indiscriminately and not according to the law just enunciated.

In selecting a repairing system, it is therefore not necessary to consider how to restore the strength of the plate at the places where the cracks are; what is necessary is to restore the original tightness.

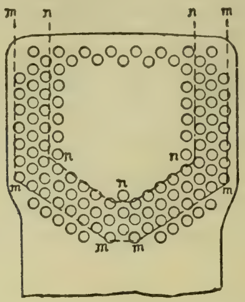

Fig. 6.

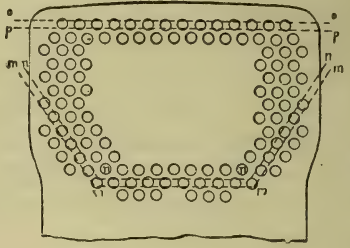

Fig. 7.

No determination, based on the real stresses acting on it, of the resistance of a tube-plate has ever been made; it will never be possible to make such a determination.

By taking into consideration the observations made as to the definite position of the cracks, we may be able to investigate how to have the holes spaced better in the strained part; in this way it may perhaps be possible to reduce the cracking.

The movements of expansion and contraction mentioned above, are due more especially :

1° To unequal expansion of the tubes and of the barrel; it is therefore better to use steel tubes than copper tubes (1);

2° To the wear of the beading of the tubes, easily determined to occur first in the lower rows, so that the perforated part no longer so much stiffened by the beads of the tubes, is more apt to suffer from forward and backward movements, more or less permanent, which produce damage in the interspaces near the edge of the perforated zone.

This action is more marked in the parts near the circumference, and the parts are probably coincident with the bending points of the elastic curves of the different sections. This arises from the fact that a plate is nothing but the flat base of a vessel, a base which can be considered as fixed to its four sides. The different way in which cracks form in plates with vertical rows, as compared with those in plates with horizontal rows, shows that this induction is correct.

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(1) Although a number of managements are against the use of steel tubes, I venture to state they are wrong. This is not the place to enumerate all the reasons in favour of using steel tubes, as against copper tubes; the latter are considered more economical as the old metal is of value.

In order to secure the thick patches to the tube-plates needing repair, screwed ferrules were always formerly used, as shown in figures 8 and 9.

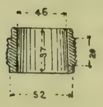


Fig. 8.

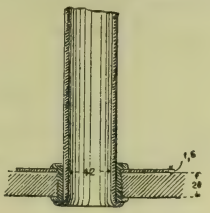


Fig. 9.

With thin sheet, after early trials with screwed ferrules, I always use plain copper ferrules (figs. 10 and 11) consisting of pieces of ordinary copper tube cut off and put in place. They are of course much cheaper than screwed ferrules.

Fig. 11.

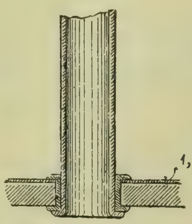
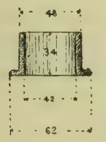


Fig. 10.



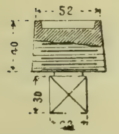


Fig. 12.

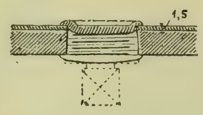


Fig. 13.

In order to obtain good work, it is necessary to examine the holes in the plate, and then expand the plain ferrules by means of a Dudgeon, Royer or other tool, either from the fire-box or the barrel side; the two beads must then be made carefully, particularly the one inside the boiler, so as to ensure the true position and correct adhesion of the patch of thin metal (1).

⁂

When the interspaces are much damaged, particularly if they have already been repaired or the tube-plates have become deformed, it is useful, when applying the thin sheet, to use screwed plugs in the holes adjoining the interspaces where there is much damage. These plugs, which hold the damaged interspace on both sides, form a united whole while the thin sheet at the same time prevents any possible leakage.

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(1) Mr. Rocca-Rey, engineer, Alexandria sheds, has devised a reamer for truing the holes in the plates; this tool expedites the work very much.

Two gears are mounted on a small support made of a piece of plate. The first axle is turned by the fitter by means of a handle, the second carries a reamer to enlarge the hole. The tool is easily secured to the tube-plate, in the position desired, by means of bolts passing through the holes in the tube-plates.

Plugs of two kinds are used. I have tried those shown in figures 12 and 13 which have been used in other shops; those shown in figures 14 and 15 I have used in different cases and always with good results.

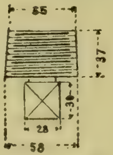

Fig. 14.

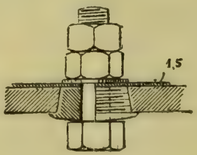

Fig. 15.

The details of the construction of this plug, which consists of a bolt and two nuts, are shown in figure 16. I may here add that when the lock nut was not used, the device easily worked loose.

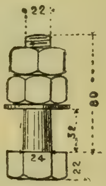

Fig. 16.

Other types of plugs have been used, but always with mediocre results.

⁂

The secret of success in repairing tube-plates, consists in the selection of sheet from 1·5 to 2·5 (maximum) millimetres ($^1/_{16}$ to $^3/_{32}$ inch) thick; greater thickness is absolutely useless and injurious.

In order to elucidate and prove this point, I will give the reasons for the choice made.

A patch 5 to 15 millimètres ($^{13}/_{64}$ to $^{19}/_{32}$ inch) thick, introduced from above into the barrel without tubes, is placed against the tube-plate. It must then be taken to the drill, and then have its face, etc., fitted by means of chipping and filing. By these different operations it always becomes somewhat distorted, so that when it is ready to go on to the plate the holes no longer perfectly agree, and a certain amount of gentle tapping is then required to get the holes into agreement without increasing other deformation.

It may be added that if the patch is rather large — as often happens — it is necessary, in order to get it inside, to take it out and again introduce it into the boiler through the dome. In such cases it has thus to be bent, a little, three times. This tends to deform it and there is even risk of fracture.

This happened at the Naples sheds one of the first times a patch 4·5 millimetres ($^{11}/_{64}$ inch) thick was used; for before arriving at the thickness of 1·5 to 2 millimetres ($^{1}/_{16}$ to $^{5}/_{64}$ inch), a series of tests were made starting at 10 millimetres ($^{25}/_{64}$ inch) and gradually reducing the thickness till it was found that sheet of 2 and even 1·5 millimetres ($^{5}/_{64}$ and even $^{1}/_{16}$ inch) was suitable. The deformation mentioned above cannot be avoided and consequently the adhesion of the patches is much imperilled.

Similarly in order to get thick patches into place, they can only be drawn against the plate by means of bolts and nuts through the holes; tapping must not be used or else there is risk of further deformation.

Thus the method of fitting the thick patches is of itself responsible for defective adhesion, which it is sought to overcome by caulking. But owing to the irregularity of the shape, caulking is not always successful.

Very frequently, the leakage through repaired plates is due to want of adhesion of the very thick patches; if then this defect results from the very way they have to be treated, the suspicion with which they are always looked upon is justifiable.

⁂

When a patch, 1·5 to 2 millimetres ($^{1}/_{16}$ to $^{5}/_{64}$ inch) thick, is after careful annealing applied to the surface of the tube-plate and pressed against the holes, it is fixed provisionally by bolts and nuts, and then light blows are given with a fitter's hammer at the holes. These places are, therefore, swelled out a little and pressed into the plate. The sheet being left in position, the holes are cut by means of a chisel and the edge of the patch finished off, which thus becomes perfectly caulked along its edges by the cutting itself.

These operations can be carried out without taking the patch away from the tube-plate, because the sheet has but a limited thickness; so that after the holes which are to receive the ferrules are finished off by filing and the plugs, if any, inserted, the patch is ready and in position.

When thin sheet is used, it is not necessary to take into consideration any bulges or hollows in the plates, for the sheet can be readily be adjusted to irregularities without endangering the adhesion of the patch and without affecting its tightness. And this agrees with what has already been stated : it is bad practice to want to correct any bulging in the perforated parts of the tube-plates, and yet this is necessary, when thick patches are used, to ensure their adhesion.

The fact that work is done on the patch when in position (work easy and quick of execution) helps to make the patch adhere tightly to the plate. Given its limited thickness, whatever means be used, the patch can easily be placed againt the plate, to which it fits accurately; for it is either thinner than, or as thick as the fastenings holding it in place : namely ferrules of copper tube 2·5 to 3 millimetres ($^3/_{32}$ to $^1/_8$ inch) thick.

It must also be noted that in this way we obtain the proper relative strength, which according to the elementary principles of machine construction must never be absent, which the practical man determines at a glance, but which the engineer must, when required, be able to determine by calculation.

When thin sheet, 1·5 to 2 millimetres ($^1/_{16}$ to $^5/_{64}$ inch) thick is used, 2·5 to 3 millimetres ($^3/_{32}$ to $^1/_8$ inch) copper ferrules are satisfactory and well proportioned; whereas when screwed ferrules are used and a thick patch, there is no proper relation. Finally, there can be no comparison between threaded ferrules and plain pieces of tube from the point of view of economy of work and material.

⁂

Under the most unfavourable conditions, in the case of tube-plates in very bad condition, only fifteen to twenty days' work have been required to take out the tubes, put on a patch over a surface of eighty to ninety holes, and put in the tubes again; at the same time, other minor repairs were also carried out at the sheds, and all that with a considerable saving in the maintenance and without having the locomotive stand idle for months at the main shops.

The operation, in the case of the largest patches (up to ninety holes), only cost 300 to 400 francs (£12 to £16) for materials and labour (taking out and replacing the tubes included); in the smaller and more generally occurring cases (twenty to fifty holes), the cost was very much less. It may be remarked that when the locomotive is sent to the main shops, instead of being repaired at the sheds, the tubes are always renewed; so that the cost of changing tubes should not be considered in the case of repairing plates still to be used. It is unnecessary to prove at this point that tube-plates should be repaired before they are replaced; this has been considered at length at the beginning of this paper.

One precaution which is absolutely necessary and which the head of the sheds or of the main shops must never neglect, is to examine the surfaces of the plates to which the patches are to be applied, and after the latter have been applied and before the tubes are replaced, to try all the ferrules, by tapping them inside with a hammer, to see that they are tight. This advice may seem superfluous, but the bad results obtained when repairing engines generally, especially boilers, are often due to want of proper supervision. In the case of boilers the most minute details must be carefully attended to.

It may be observed that as regards boiler makers' work, it is impossible to recommend too much care; this recommendation has never been omitted by the authors dealing with the subject, among whom we may quote Mr. Keromnès, who states that to do proper boiler makers' work is to take sufficient pains; we can even wholly agree with Mr. Verole (¹), when he says that if we compare the work of repairing boilers with the work of constructing them, the former is, as a rule, more difficult and requires greater skill and care; this author justly remarks that in such work there is greater responsibility, seeing the economical factors involved.

* * *

Referring to the remarks already made, the important fact also results that there is a great advantage in repairing plates even if the cracks are only superficial, for future troubles and losses are avoided.

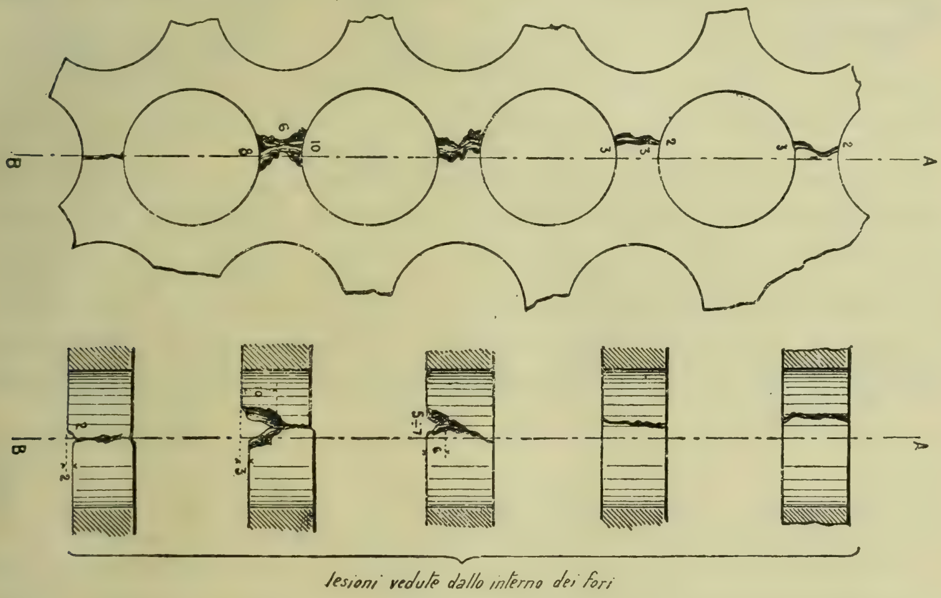

Fig. 17.

Explanation of Italian terms: Lesioni vedute dallo interno dei fori = Cracks showing in the walls of the holes.

Plates, even if the cracks have only just started, leak. The ferrule, which is inexpensive and easily inserted to hold the thin sheet, by its double bead covers the walls of the tubes where the interspaces are damaged, and so prevents the leakage of water

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(¹) In the paper already referred to.

and steam which often occurs, even if the tubes are well fitted and properly expanded.

To repair a tube-plate by means of a patch of thin sheet, is almost equivalent to renewing the plate, particularly as it has already been subjected to one deformation, and will consequently suffer no further appreciable deformation. The engine driver, therefore, will have no further reason to complain of the existence of leaks and the boiler makers will no longer have to go out on to the road to repair the leaks of locomotives out at work, etc.

I need not here refer to the good results obtained on hundreds of plates, from 1900 onwards at several sheds and works in Italy, after the initial difficulties had been overcome.

In the early days, I have executed repairs of a quite exceptional character in order to ascertain what possible limit there was and to enable me to grasp all the doubts expressed by authors and locomotive engineers on the general subject of repairing tube-plates.

One of these plates had the interspaces damaged as shown in figure 17. This plate was repaired and the locomotive was then used for one year for the through trains on the Rome-Naples line; it was then sent to the shops not because the repaired plate failed, but because one of the cylinders gave way.

Nearly all the earlier tube-plates repaired had a certain number of interspaces in a similar state, so that plugs and screwed ferrules were often used where there was most damage.

Figures 18 to 23 show some of the earlier plates repaired at Naples; they are selected to show what good results can be obtained with this class of work, if the engineer is careful and proper supervision is exercised by him. These plates illustrate what has already been stated as to the usual location of the cracks according to arrangement of tubes.

Figures 18 to 21 are instances of the figure 6 type, and the others of the figure 7 type.

I do not advise that the same should be done everywhere; the more so as with proper maintenance a plate should be repaired before it gets into such a state.

But I had to take over the management of sheds with 110 locomotives at a time when, owing to want of sufficient stock, the locomotives were kept in use as long as possible, so that many plates showed cracks. Now that only made things all the worse; I had to combat and overcome the prejudices, not only of the locomotive crews who were afraid to take out a locomotive with a repaired tube-plate, but also of others, and I attempted the most difficult repairs in order to prove that the system was suitable.

Under these conditions it was ventured, in the case of a plate where there was a fracture at the angle, to apply a patch of thin sheet and strengthen it by a piece of plate 7 millimetres ($^{9}/_{32}$ inch) thick (fig. 18), over a length of some 10 centimetres (4 inches). In this case, it was necessary to use the thicker material, for it was necessary to strengthen the broken section which extended beyond the perforated part.

If however a plate which at the first renewal of the tubes shows signs of cracks is protected and repaired in good time over the critical zone shown in figures 6 and 7, it will give no trouble during several years, particularly with careful firing.

Fig. 18.

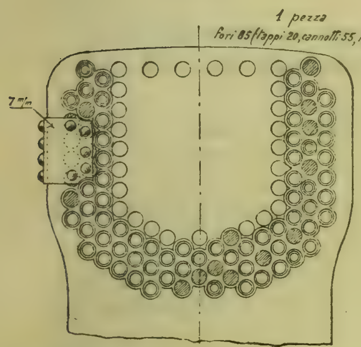


Fig. 20.

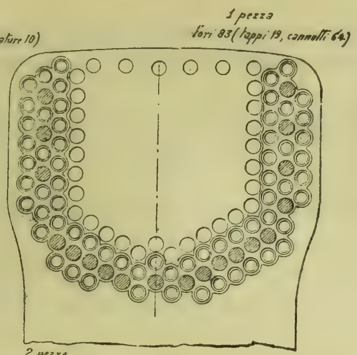
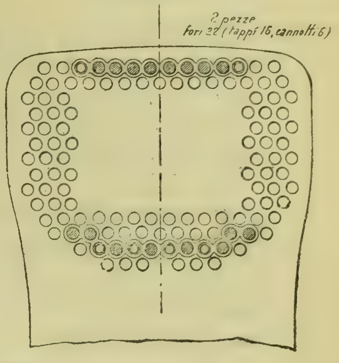


Fig. 22.



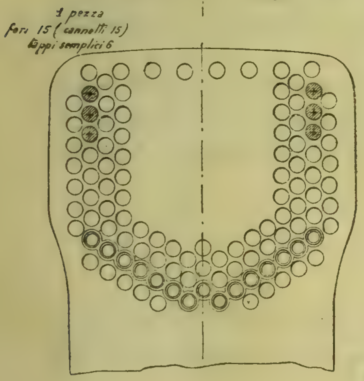


Fig. 19.

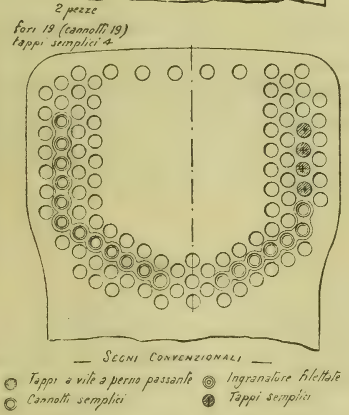


Fig. 21.

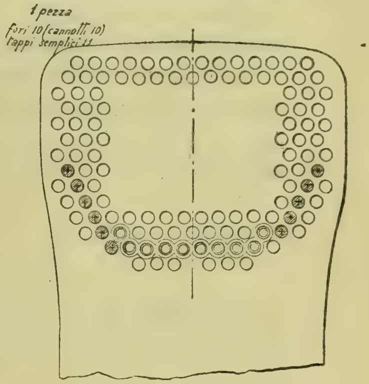


Fig. 23.

Explanation of Italian terms: Cannotti semplici = Plain ferrules. — Fori = Holes. — Ingranature filettate = Screwed ferrules. — Pezza = Patch. — Segni convenzionali = Reference. — Tappi a vite a perno passante = Bolts and nuts. — Tappi semplici = Screwed plugs.

If we tried to make the interspaces near the outside of the perforated part stronger, I think we might hope to prolong the life of tube-plates. What tends to shorten this life is not merely the bad quality of the metal, but more often want of care in firing.

As the railways in Italy mostly are in very undulating country, the latter point is of great importance.

The first cracks which form in the tube-plates on the fire-box side are always included in the spaces marked in figures 6 and 7; in figure 6 they as a rule appear at the bottom, near the two angles, in figure 7, at the bottom, near the middle.

Even when there is considerable oozing and leaking, the cracks seldom extend right through the interspaces; leakage can take place if the cracks extend only halfway through.

Now when the interspaces of a tube-plate begin to show cracks, the plate can still be in two states :

1° The tubes are still in good condition; then one of the methods described should be tried to use them some time longer and then take them out and apply a patch of thin sheet;

2° The tubes require partial renewal; it is then advisable to renew all of them and apply a patch.

In some cases and with skilful men, the central tubes can be left in place and the patch applied nevertheless.

However limited the number of cracks (say for instance bottom corner only), it is advisable to apply a single patch to cover all the critical spaces shown in figures 6 and 7 respectively.

When cracks begin to form in a plate they will nearly always extend over the corresponding critical space.

Only in the case of new plates which are in quite good condition but with a few solitary cracks, can small patches be used, extending over a few holes, with ferrules; for in such a case the tubes will become worn out and have to be renewed before other and more important cracks become formed.

Conclusion.

In conclusion we may state, that every confidence can be placed in tube-plates repaired, according to the system described, by means of thin copper sheet and ferrules.

With regard to these repairs, the following should be noted :

1° They are very useful when carried out at the locomotive sheds, and often also at the main shops when it is more particularly a question of plates showing rudimentary cracks only;

2° The pieces of sheet used should never be more than 1·5 to 2·5 millimetres ($^1/_{16}$ to $^3/_{32}$ inch) thick; if thicker, the success of the operations is endangered, particularly if of a certain magnitude;

3° In the case of plates with holes arranged in rows, separate pieces of sheet must never be used for the two sides, but the sheet should always have a U shape suited to the space most subject to damage. Only when dealing with a plate with rudimentary cracks, when it is probable that the repairs can stand until the tubes are renewed, can small pieces of thin sheet be used, the larger piece being put in when the tubes are renewed;

4° The patches of thin sheet should always be secured to the plate by means of plain copper ferrules; in exceptional cases, a few screwed ferrules may prove useful.

When large patches are put on, then in addition to the thin plain ferrules it may be advisable to use screwed plugs and bolts, the latter being placed near the very cracked portions;

5° The engineer or officer in charge must personally supervise the work and see that great care is exercised.

If these rules are observed, it is certain, even in the case of very damaged plates, that it will be possible to continue to use the locomotives, no matter for what class of work, for at least two years longer. And that after keeping the locomotive idle, while the plate is being repaired, only fifteen to twenty days, and at an expenditure which will never exceed 300 to 400 francs (£ 12 to £ 16).

In this way, fewer locomotives have to be sent to the main shops for general overhaul, the time during which they are not actually at work is reduced, and a great deal of material is utilized, which would have to be renewed if the repairs were carried out at the nain shops.

The autogenous soldering of the cracked parts of the plates is impracticable, unless indeed a means for preventing the conduction of heat around the parts heated for soldering were discovered; I was unsuccessful in all the attempts I made to obtain this result.

[656 .256 (.73)]

GOVERNMENT REPORT ON THE BLOCK SYSTEM IN THE UNITED STATES.

(From *The Railway Gazette.*)

Automatic stops.

Automatic stops are in use on the Boston Elevated Railroad and on the express tracks of the New York City subway. Neither of these lines is interstate, but the applications are of interest as illustrating the practical working of automatic stops, although their use on steam railroads would unquestionably be attended with many serious difficulties not met with under the special conditions of city rapid transit lines. The devices used are practically the same on both of the lines named. An arm or trip is placed alongside the rail, and so arranged that it lies below the top of the rail when the signal is clear, and is raised above the top of the rail when the signal indicates stop. The trip, like the signals, is operated electro-pneumatically. On the cars are valves in the brake-pipes having levers projecting downwards, so as to come in contact with the trips when the latter are raised. The striking of a valve lever against a trip opens the valve, allows the air to escape from the main brake-pipe and so, by the regular working of the automatic air-brake, causes the application of the brakes on all the cars and the stopping of the train.

Another automatic stop was used on the elevated railroad at the World's Fair, Chicago, and for several years, on two of the elevated roads in Chicago; it was also tried to a limited extent on a few standard railroads. This device included a trip and an air valve in the brake-pipe, but the design was quite different from that mentioned in the preceding paragraph, and was made with more particular reference to the conditions on standard steam railroads.

A system that may be regarded as a modification of the automatic stop, and which has been tried by a few railroads, uses an electric circuit completed through a contact device placed near the rail to actuate the mechanism, which shuts off the steam on the locomotive and applies the brakes of the whole train. With this system, howewer, it is in the power of the engineman to open the throttle and release the brakes as soon as the device has operated, so that he can provent the train from stopping, or can regulate the speed so as to make the stop at any desired point. Thus the apparatus performs the function of calling to his duty an inattentive engineman, while yet not causing excessively sudden or unnecessary stops.

Automatic stops, except those of the class last mentioned, act independently of the engineman, and bring the train to a stop before they can be released. They are, therefore, in the nature of emergency appliances, intended to stop a train before it reaches a point of danger if the engineman fails to do this himself. Obviously the automatic stop must act at such a distance from the actual point of danger that the train can be brought to a stop by the brakes before reaching that point. And if, in the ordinary course of operation, the engineman is to bring the train to a stop before the automatic device can come into action, the stopping point must be arbitrarily moved back, and the signal erected at the point where the trip or contact for the automatic stop is placed. Ordinarily, then the engineman will stop at a point (the " home " or stop signal in its new location) a safe stopping distance away from the place where the stop signal is usually located; but if, for any reason, he fails to do so, the train will still be automatically stopped short of the point beyond which it cannot safely run. The automatic stop that can be released at once by the engineman, does not necessarily require any change in the location of the signals. The actuating device would naturally be placed at the distant signal (the signal set 100 or 200 rods back as a warning that the stop signal is being approached). In case the engineman should fail to do anything himself towards stopping the train, the automatic appliance would make the stop short of the home signal. But, if the engineman is in possession of his faculties and is attending to the running of the train when the distant signal is reached, he can prevent an emergency stop and bring his train up to the home signal, exactly as he could if the automatic stop was not there. A disadvantage of this is that the stopping device does not guard against miscalculation or the result of unforeseen conditions that may make it impossible for the engineman to stop as he intends; it is fully effective only in case he is asleep or dead, or for any other reason fails to act when he passes the distant signal. But by the use of a proper recording device, used in connection with the stop to check the action of the engineman, this disadvantage may be in a measure overcome.

It seems clear, then, that an automatic stop, to provide for all contingences, should be absolute; and, in that case, as already pointed out, there must always be a section of " dead " track in the rear of every danger point, or, with automatic block signals, moving trains must be practically one block farther apart than they need be under present actual practice. This means a very decided reduction in the capacity of the road; that is, the number of trains that can be moved over it in a given time — a condition that in extreme cases would necessitate a costly increase of track facilities. It is this serious loss in capacity of the road, and, in addition, inconveniences that would result from stopping trains at a distance from the proper stopping points, with many practical difficulties in the application and operation of automatic stops, that has prevented any use, in ordinary railroad service, outside the experimental field, of an appliance so desirable theoretically.

It is undeniable that collisions on our railroads could be reduced to an exceedingly small number by the efficient management of block signals as now used, including well-known, well-tested and generally approved safeguards; it is also unquestionable that an efficient automatic stop would prevent that last small percentage of such accidents as are due to the engineman falling dead at his post and other like causes.

Conclusions and recommendations.

Under questions 7, 8 and 9 in its order of August 24, the commission sought to obtain information from railroad officials concerning the economy of the block system, the extent to which it had reduced the number or cost of collisions, and how far it had increased the capacity of their lines.

The answers to these questions have not been, in all respects, entirely satisfactory. Many railroad officials have freely expressed themselves in favor of the block system, and the manager of one of the most important systems of railroad in the country, on which automatic block signals of the latest type have been installed very extensively within the past few years, declares unequivocally that the investment which his company has made in this direction is one of the best that it has made in any department. A great many managers, however, appear reluctant to make positive statements with respect to the actual results attained from the operation of the block system on their lines.

It appears that the block system has been introduced from mixed motives. One road, for example, will incur the added expense of several hundred dollars per mile per year because it has been mulcted a considerable sum for damages in a collision of passenger trains; another will introduce the system because of numerous lesser collisions of freight trains, causing much loss and showing the likelihood of greater loss. Another will emphasize the feature of reputation, knowing that passengers will feel safer under a scientific system, and this feeling will influence their patronage. If a competing line already has block signals, this argument may be forced on a manager. Another manager, particularly sensitive to the reputation of his road, will be influenced by the effect on his subordinates and on his own peace of mind. They all breathe more freely after getting rid of the anxieties incident to the time interval and flagging system.

The salient facts shown in the statements which have been received from carriers are that :

1° Fifty of the principal railroads of the country have introduced and are using the block system on their important lines, though with considerable difference in details of apparatus and methods of operation;

2° The telegraph block system is operated at moderate expense, with a great improvement in safety as compared with former methods of train control;

3° Automatic block signals, almost universally looked upon in this country as the highest exemplification of the art, have been and are being developed with great energy and skill and liberal expenditures of money;

4° Automatic signals are superseding the telegraph block system to some extent, and seem destined to do so increasingly in the future;

5° Thirty roads of considerable length and importance have not yet adopted block signals of any kind;

6° The block system has proved decidedly profitable even on lines where the signal equipment is not complete, this being accomplished by careful adherence to modifying rules making provisions against the deficiencies of the block system, and by the continuance of the train despatching regulations which were used before the block system was adopted.

It is proper to add that all of the railroads continue in force their rule requiring that when a train is unexpectedly detained, a flagman shall go back with a red flag or lantern to stop any following train; though, as the accident records show, flagmen have repeatedly failed to stop trains that have wrongfully passed block signals.

The main facts which have been elicited concerning the present policies of the railroads of the country in respect to block signalling are :

1° The principal railroads use the block system on their lines of heaviest traffic, and most of them report that it is economical;

2° Many of these roads use it also on lines of light traffic and some are rapidly extending it;

3° All railroad officers deem the system an improvement over any other method of guarding against collisions. In other words, they consider it a means of safety;

4° Many say that it has reduced the number and cost of collisions.

Those who do not testify on this last point simply plead ignorance, saying that their records are imperfect. One reason why some of the roads do not keep records of the results of the block signal system is, no doubt, that they are convinced that as a means of safety, it is an improvement over the old system without statistical proof. Another is that its benefits consist partly in an amelioration of unfavorable conditions which cannot be definitely compared one period of time with another. It is probable that one reason why records are withheld on the plea of incompleteness or slight inaccuracies is that they show the prevalence of permissive blocking or other practices not generally approved.

The various conditions under which the different block signal methods are used may be observed by considering briefly the practice on typical roads as follows :

The controlled manual system is used on the four-track lines of the New York Central & Hudson River and the New York, New Haven & Hartford. These are the principal examples of this system in the United States. It is, of course, equally adapted to two-track lines. The electric train staff, which is a type of controlled manual apparatus, is used on 100 miles of a single-track division of the Southern Pacific and on short sections of other roads. The train staff is universally approved as a safety device, but its failure to secure more general recognition appears to be due to a general feeling that the controlled manual apparatus which is used on double-track lines is perfectly adapted to single-track work, and is superior to the staff in that trains need not be stopped or slackened for the purpose of delivering the staff.

The telegraph block system, the cheapest method in use, is found on four-track sections of the Pennsylvania Railroad (though according to the present policy of the road these signals will in the near future be supplanted by automatic signals) ; it is used on double-track lines by the Baltimore & Ohio, the Pennsylvania, the Chicago, Burlington & Quincy, the Chicago, Milwaukee & St. Paul, the Chicago & North-Western, the Erie, the New York Central Lines, the Philadelphia & Reading and a number of roads of less importance than these. The telegraph block system is used extensively on single-track lines of the Atchison, Topeka & Santa Fe, the Bessemeer & Lake Erie, the Chesapeake & Ohio, the Chicago & Alton, the Chicago Great Western, the Lehigh Valley, the Norfolk & Western, the Northern Pacific, the Southern, the St. Louis & San Francisco, and on the lines just mentioned as using it on double track.

The automatic block system is in use on the four-track lines of the Boston & Albany, the Boston & Maine, the Central of New Jersey, the Pennsylvania, the Philadelphia & Reading and the Pittsburg & Lake Erie. It is in use on double-track lines of these roads and of the Baltimore & Ohio, the Chicago & Alton, the Chicago & Eastern Illinois, the Chicago & North-Western, the Delaware, Lackawanna & Western, the Illinois Central, the Lehigh Valley, the New York Central Lines, the New York, New Haven & Hartford, the New York, Ontario & Western, the Southern Pacific, the Union Pacific and on short sections of fourteen other roads. It is used on single-track lines of the Chicago & Alton, the Cincinnati, New Orleans & Texas Pacific, the Delaware & Hudson, the Missouri Pacific, the Oregon Short Line, the Oregon Railroad & Navigation Co., the Southern Pacific and the Union Pacific, and on short sections of four other roads.

With regard to the telegraph block system, most of the roads using it show records of long continued immunity from collision, but the thirteen collisions which are referred to in this report, with others occurring more recently and still fresh in the public mind, compel us to recognize that the system is not perfect.

The only reason specifically formulated by any railroad manager for not introducing the block system is financial inability, except in the case of lines on which the passenger business is extremely light. Looking at the policies of some roads as they are known, and at others in the only way in which they can be interpreted in the light of facts, it is quite clear that, generally speaking, the roads which have been dilatory in adopting the block system or in extending its use, have simply pursued that temporizing policy which postpones appropriation of money until necessity will permit of no further postponement. An appropriation for the erection of block signals or for the expense of maintaining them is not viewed with favor because railroads operating without such signals have, in many cases, made fair records for a long time. It is true that important railroads have carried thousands of passengers for many years, with no block system, without fatally injuring a single one of them in a collision. Such a record is justly regarded with pride; but a single collision ten years hence, which is an admitted possibility, would extinguish the pride and becloud the record of the past.

Many important roads have introduced the telegraph block system with the expenditure of very little money, simply by establishing a few new telegraph offices. There are also cases where a road, which has apparently held the view that the block system is impracticable by reason of its cost, has quickly changed its policy after the occurrence of a collision on its own line. It is true that roads which introduce the block system without increasing their telegraph facilities, usually find themselves obliged, for a part of the time at least, to run freight trains under permissive blocking (which, strictly speaking, is not block signalling at all), but the action of such roads is significant because it marks decided progress. Their imperfect system protects passenger trains, and it educates trainmen to the need of a space interval for all trains.

A number of prominent roads which have shown enterprise in safeguarding their more important lines by means of block signals, are continuing the old methods on other lines. A disastrous collision in the state of Indiana in November affords a striking illustration of this fact. A few roads which enjoy ample prosperity have as yet done little or nothing in providing block signals.

The present investigation has been conducted for the purpose of setting forth the actual facts under present practices, and of affording the best guide as to what can or should be done to improve the safety of travel on the railroads of the United States. The conclusions reached confirm the views which have been heretofore expressed by the commission in its annual reports for the years 1903, 1904 and 1905. In its report for the year 1903, the commission presented the draft of a bill similar to the one introduced in the House by the Honorable John J. Esch, of Wisconsin, which provides for the introduction of the block signal system and also for the exercice of supervisory power by the commission through the employment of suitable agents and inspectors.

Supervision is necessary, not only to insure that the specific requirements of the law are complied with, but also because of differences in methods of construction and operation and in the standards of perfection and safety on different roads where the block signal system is already in use. This point was not especially emphasized by the commission at the time the bill was laid before Congress, but the present investigation has more clearly emphasized the need of such supervision. The differences of practice, etc., are reflected in the results of operation. In reporting the faults of signals and errors in operation, different companies make widely different showings. This is a vital matter in which the function of the government in securing publicity is a particularly useful one, and in which no authority other than the government can act efficiently. To investigate accidents, as is done in England and to some extent by state commissions in this country, may be called in indirect method of securing information as to the efficiency with which safeguards to life and property are administered. To investigate signals and signal practice directly, without regard to accidents, would be a more direct method of promoting safety. Accidents should be investigated, for they increase so rapidly year after year that the record is looked upon as a reproach upon our American system of railroad management; but it is even more logical and reasonable to investigate signal practice, for, as regards the worst class of accidents, namely, collisions, investigation and regulation which look to prevention are chiefly of value. Investigation to this end is needed under four heads, namely :

1° The telegraph block system on the more important roads (mainly double track) as regards the personnel and the routine; the use or non-use of distant signals, and the practice of permissive block signalling;

2° The telegraph block system on single-track lines and minor roads, as regards the personnel, the routine, distant signals and permissive signalling, and also as regards the use of time rules and despatchers' orders to make up for incompleteness in the block signalling arrangements;

3° The automatic block system should be investigated on all roads with respect to the efficiency of the apparatus and of the methods of inspection and care, and the integrity of the records of signal operations in respect to their completeness;

4° The automatic block system on single-track lines should be investigated with respect to the features named in the foregeing paragraph, and also as regards the use simultaneously with the block signals of despatchers' orders, and other measures designed to prevent collisions irrespective of the block signal system.

If legislative enactment should not require the early introduction of the block system on all railroads, government inquiry should be pursued with a view to determine the necessity for its installation on particular lines or parts of lines on which it is not now in use. The principal and, indeed, the only argument against the enactment of a compulsory block signal law is that a large number of railroads are now making fair progress in the extension of block signals without compulsion. Certainly the roads which come within this class can have no fault to find with such a mild measure of compulsion as that provided for in the bill proposed by the commission; while as to roads which have taken no action, some compulsion should be employed to require them to bring their service up to a proper standard within a reasonable time.

The question of the need of apparatus for automatic control of trains, is a somewhat difficult one. Collisions occur occasionally under both the telegraph and automatic block systems, which an efficient automatic stopping apparatus might prevent. The locomotive engineman has most exacting duties. An individual runner may be far above the average in mental poise and moral character, and yet many fail in vigilance or in judgment occasionally, and such failure may mean disaster. Again, the individual engineman may be efficient in a high degree, and yet the efficiency of a force of enginemen as a whole may be unsatisfactory. The engineer performs such an innumerable succession of important acts on every trip that, even with an infinitesimal percentage of failures, the 40,000 or 50,000 engineers of the United States may still be chargeable in the course of a year with a large aggregate of fatal and non-fatal injuries. Anything less than perfection is cause, at least, for investigation, if not for decided dissatisfaction. Every great accident due to an engineman's fault is followed by a strong public demand for the introduction of automatic train stopping devices. As previously shown in this report, such devices used to a limited extent, though not interstate roads, seem to have given a fairly good account of themselves, but these records do not justify the commission in making any recommendation as to their use or non-use, without a more thorough and complete investigation.

The limited extent to which devices of this character have been used, makes it practically impossible for the commission to obtain anything more than theoretical and technical knowledge concerning them. It is therefore apparent to the commision, that Congress cannot be furnished with much further information concerning these appliances, which would appear to be extremely valuable, theoretically, without extensive tests conducted by officials of the government and at government expense. For this reason and because the resolution under which this inquiry has been made does not confer authority to make such tests, the commission, on January 3, 1907, addressed a communication to Congress, recommending that supplemental legislation be enacted authorizing the commission or some other official body to supervise and conduct experimental tests of such safety devices as appear to be meritorious, and that an appropriation be made sufficient to secure the most competent experts and defray the other expenses incident to such a project. The commission can only repeat this recommendation, believing that such experimental tests would be of great value in determining the direction which legislation not now recommended should take in seeking to add to the safety of railroad operations.

The recommendations of the commission for immediate or early legislation are summarized as follows :

1° That the use of the block system should be enforced on the passenger lines of the country in general according to the provisions of a bill in the substance of the one submitted to the Congress by the commission in December, 1903, (¹) ... except that the time to be allowed for final compliance with its compulsory features, should be made three or four years from the present;

2° That with or without the passage of a law requiring the use of block signals, there should be a law authorizing an official investigation of train accidents, and providing for the employment of competent men to perform the duties imposed by such an enactment;

3° That investigation by official tests of automatic appliances for the control of railroad trains should be authorized in accordance with the commission's recommendation of January 3, 1907, with an appropriation of sufficient amount to conduct such tests in a proper manner.

(¹) *Railroad Gazette,* January 1, 1904, p. 14, and *Bulletin of the Railway Congress,* No. 4, April, 1904, p. 340.

MISCELLANEOUS INFORMATION

[621 .132.3 & 621 .132.5]

1. — Locomotives for the Italian Government Railways.

Figs. 1 to 12, pp. 737 to 739.

(*The Railway Age.*)

The Baldwin Locomotive Works have recently completed twenty locomotives for the Italian Government Railways. Half the number are of the consolidation type with single expansion cylinders, and half of the ten-wheel type with balanced compound cylinders. The principal features of the engines are shown in the accompanying engravings.

As far as the general design is concerned, these locomotives closely follow American practice. A number of details, however, have been modified to suit the railroad company's design. The cabs are steel of the canopy type. A screw reverse mechanism is used. The special equipment includes Friedmann injectors, English-Westinghouse air brakes and "Italian type" Coale muffled safety valves. Whitworth standard threads are used for all bolts and nuts. The screw couplers, drawhooks and spring buffers conform to designs furnished by the railroad company. All the driving-wheel centers are of cast steel, with tires held by retaining rings. The engine truck and tender wheels are of solid rolled steel, made by the Standard Steel Works. The rims are sufficiently thick to enable tires to be shrunk on when the diameters have become sufficiently reduced by wear. Both types of engines are fitted with steam heat equipment. All the boilers are straight top, those for the consolidation engines having wide fire-boxes, while the ten-wheel engines have narrow fire-boxes. Five locomotives of each type have fire-boxes of copper, while steel is used in the remainder. The boiler drawings for the consolidation engine show a copper fire-box, and those for the ten-wheel engine a steel box. The fire-door opening is formed with a cast steel ring, to which both the inside and outside sheets are riveted. The grates are of the usual rocking type, with drop plates in front.

The engine frames are cast steel, of the usual bar type.

All the engines are equipped with the Stephenson link motion. The high-pressure cylinders of the ten-wheel locomotives drive the leading pair of wheels, while the low-pressure cylinders drive the second pair. The high-pressure cylinders have a stroke of 24 inches with relatively short main rods, while the stroke of the low-pressure cylinders is 26 inches. The ratio of the cylinder volumes is 1 to 2·82. Apart from the difference in stroke, the cylinders are similar to those used on previous balanced compound locomotives built by the Baldwin Locomotive Works. All four guides are braced by one guide bearer. The crank axle is of the Z-form, forged in one piece. The tenders are of the usual type, having U-shaped tanks, and frames built of 10-inch steel channels.

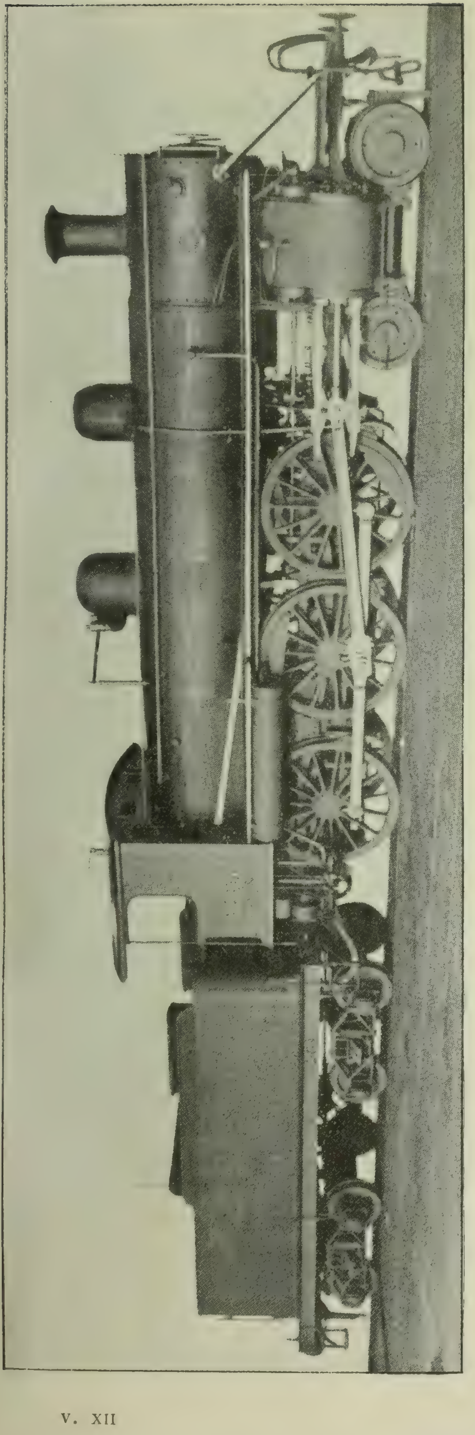


Fig. 1. — Ten-wheel locomotive for the Italian Government Railways.

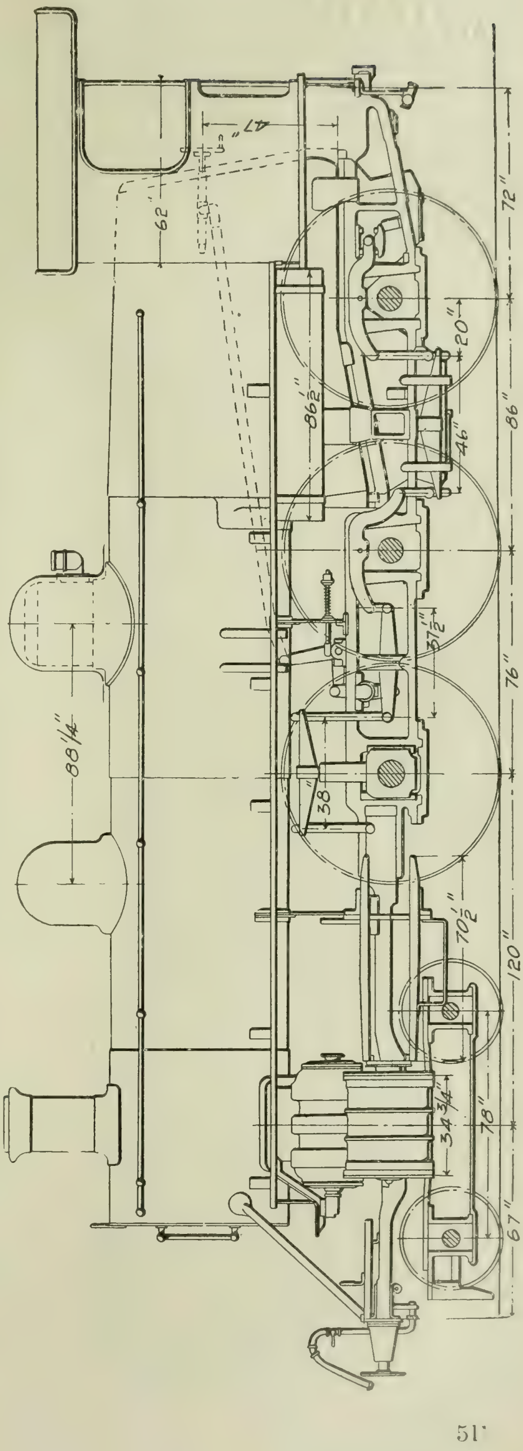


Fig. 2. — Ten-wheel locomotive for the Italian Government Railways. — Side elevation.

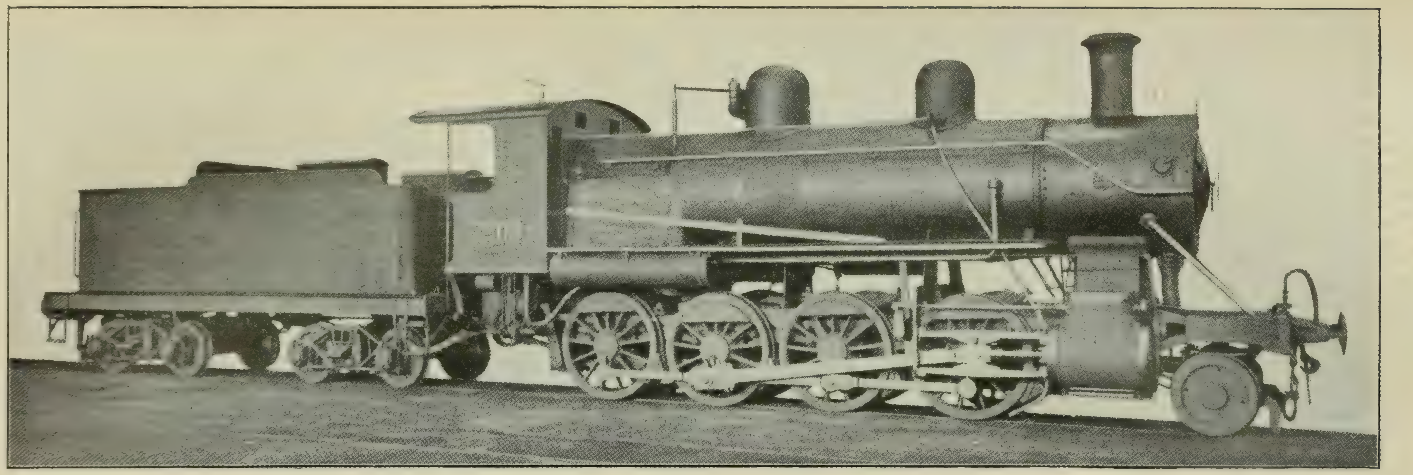


Fig. 3. — Consolidation locomotive for the Italian Government Railways.

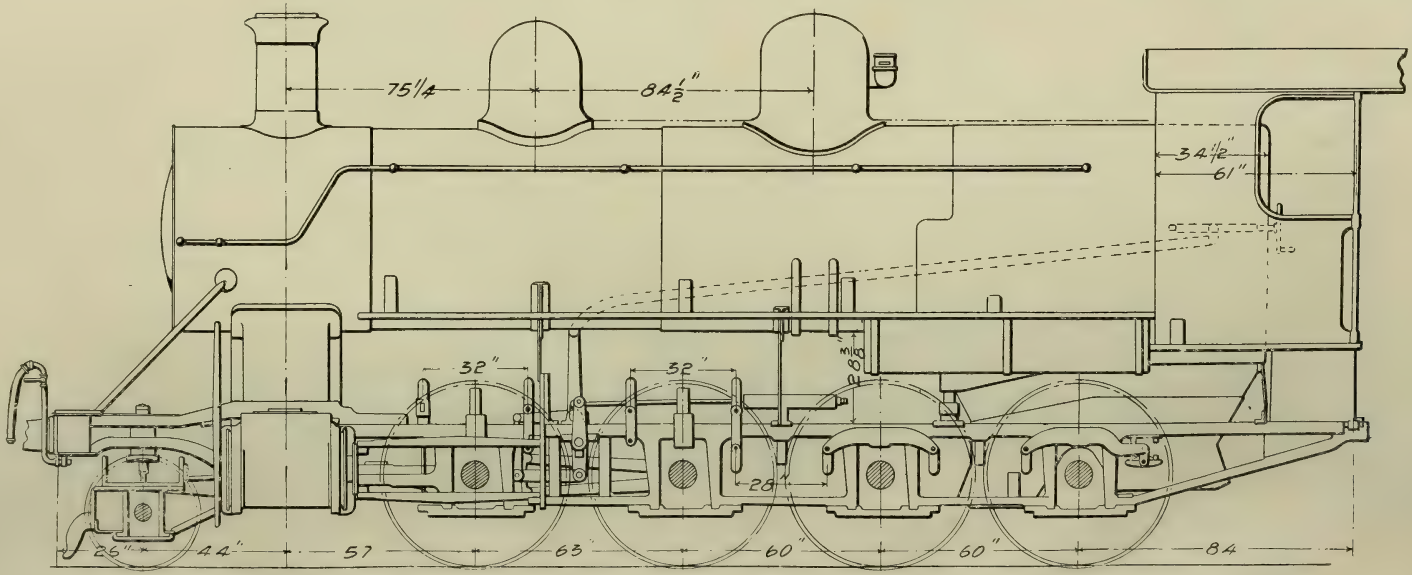


Fig. 4. — Consolidation locomotive for the Italian Government Railways. — Side elevation.

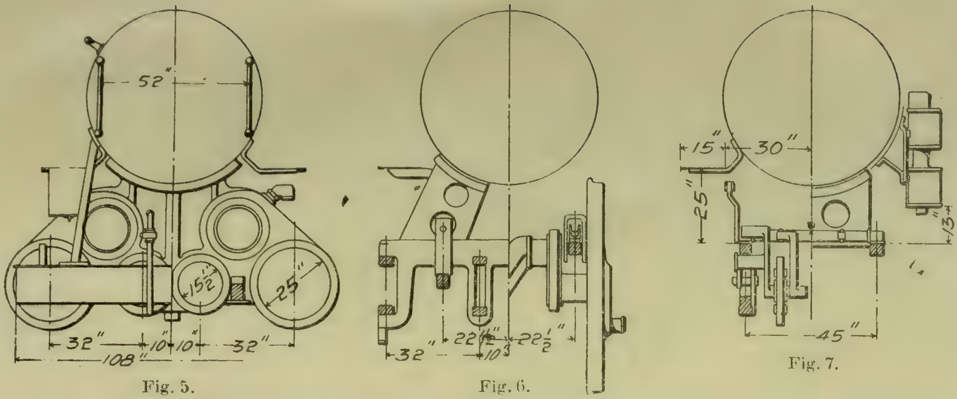


Fig. 5.

Fig. 6.

Fig. 7.

Figs. 5 to 7. — Ten-wheel locomotive for the Italian Government Railways. — Cross sections.

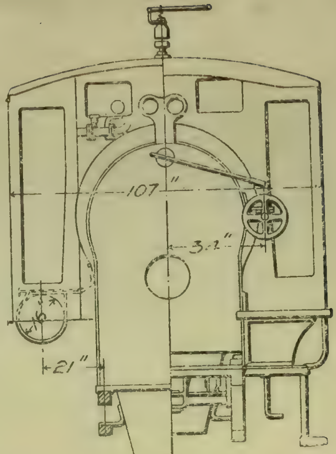


Fig. 8. — Ten-wheel locomotive for the Italian Government Railways. — End elevation.

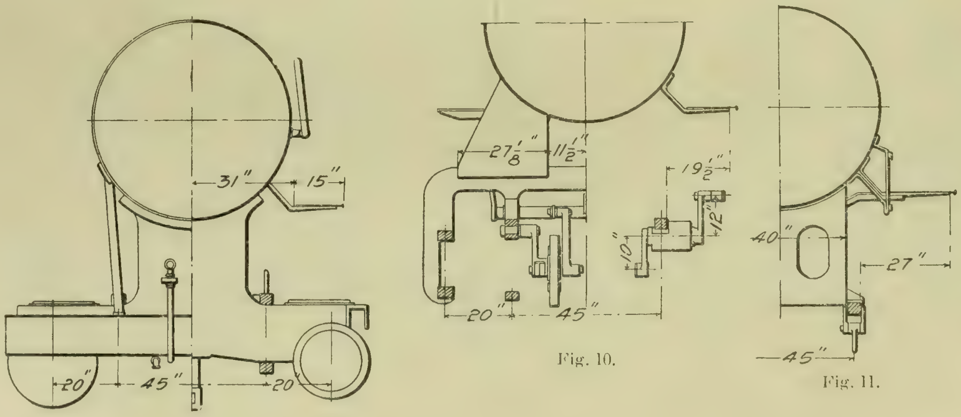


Fig. 9.

Fig. 10.

Fig. 11.

Figs. 9 to 11. — Consolidation locomotive for the Italian Government Railways — Cross sections.

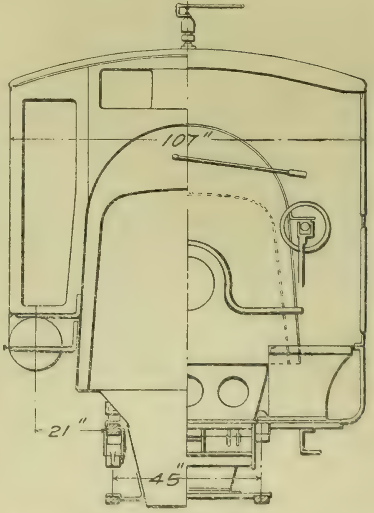


Fig. 12. — Consolidation locomotive for the Italian Government Railways. — End elevation.

The principal dimensions of the ten-wheel engines are as follows :

Gauge	4 ft. 9 in.
Cylinders :	
Hight pressure	15 $^{1}/_{2}$ × 24 inches.
Low pressure	25 × 26 inches.
Valve	Piston.
Boiler :	
Diameter	60 inches.
Thickness of sheets	$^{5}/_{8}$ inch.
Working pressure	200 pounds.
Fire-box :	
Material	Steel.
Length	114 $^{3}/_{16}$ × 42 $^{3}/_{8}$ inches.
Thickness of sheets, sides and back	$^{5}/_{16}$ inch.
— of crown	$^{3}/_{8}$ —
— of tube	$^{1}/_{2}$ —
Water space : front, 4 inches; sides and back, 3 inches.	
Tubes :	
Material	Iron.
Wire gauge	No. 12.
Number, 250 ; diameter, 2 inches ; length, 15 ft. 6 in.	
Heating surface :	
Fire-box	150 square feet.
Tubes	2,018 —
Total	2,168 —
Grate area	33·25 —
Driving wheels :	
Diameter, outside	72·83 inches.
Journals : main, 9 × 10 inches; others, 8 $^{1}/_{2}$ × 9 $^{7}/_{8}$ inches.	
Engine truck wheels : diameter, 33 inches, journals, 5 $^{1}/_{2}$ × 10 inches.	
Wheel base :	
Driving	13 ft. 6 in.
Total engine	26 ft. 9 in.
— and tender	55 ft. 6 in.
Weight :	
On driving wheels, estimated	99,000 pounds.
On truck, front, estimated	47,000 —
Total engine, estimated	146,000 —
— and tender, estimated	262,000 —
Tank capacity	5,280 gallons, 6 tons coal.
Tender wheels	33 inches, diameter ; journals, 5 × 9 inches.

The principal dimensions of the consolidation engines are as follows :

Cylinder	20 × 26 inches.
Boiler :	
Diameter	60 inches.
Thickness of sheets	$^{5}/_{8}$ inch.
Working pressure	200 pounds.

Fire-box :	
Material	Copper.
Dimensions	90 × 60 inches.
Thickness of sheets, sides, back and crown	$^{1}/_{2}$ inch.
— of tube	1 inch.
Water space, front, 4 inches; sides and back, 3 inches.	
Tubes :	
Material	Iron.
Wire gauge	No. 12.
Number, 260; diameter, 2 inches; length, 14 ft. 6 in.	
Heating surface :	
Fire-box	122 square feet.
Tubes	1,962 —
Total	2,084 —
Grate area	37·5 —
Driving wheels :	
Diameter	55 $^{1}/_{8}$ inches.
Journals	8 $^{1}/_{2}$ × 9 $^{7}/_{8}$ inches.
Engine truck wheels :	
Diameter	33 inches.
Journals	5 $^{1}/_{2}$ × 10 inches.
Wheel base :	
Driving	15 ft. 3 in.
Total engine	23 ft. 8 in.
— and tender	53 ft. 5 in.
Weight :	
On driving wheels, estimated	132,000 pounds.
On engine truck, estimated	15,000 —
Total engine, estimated	147,000 —
— and tender, estimated	263,000 —
Tank capacity	5,280 gallons water, 6 tons coal.
Tender wheels	Diameter, 33 inches; journals, 5 × 9 inches.

[625 .232]

2. — Steel passenger car, New York Central & Hudson River Railroad (1).

Figs. 13 to 24, pp. 743 to 750.

(American Engineer and Railroad Journal.)

In connection with the electrification of the Grand Central terminal, New York, the all steel type passenger car for use in suburban service was adopted by the New York Central & Hudson River Railroad. One hundred and twenty-five of these cars have been built and delivered by the American Car & Foundry Company, and some of them been in regular service during the past two months. The car bodies were designed by the American Car & Foundry Company, the railroad company's mechanical and electrical departments arranging the general floor plan of car and the layout of electrical apparatus, brake rigging and wiring. They are arranged for operation in trains by the multiple unit system, over the electrified section of the line, all of this order being motor cars. A later order of 55 cars of similar design, which will not be equipped with motors, has been made and is now being delivered.

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(1) Steel passenger cars have been described an illustrated in this journal as follows : Illinois Central side-door suburban, October, 1903, p. 358; New York Subway, all steel car, October, 1904, p. 375; London Underground Railway, July, 1905, p. 248; Southern Railway (combination steel and wood), July, 1906, p. 260; Long Island suburban car, September, 1906, p. 340; Santa Fe postal car (steel underframe), October 1906, p. 397; Philadelphia Subway car, November, 1906, p. 440; Harriman Lines steel coach, January, 1907, p. 6; Long Island steel coach, February, 1907, p. 40.

These cars have the distinction of being the first non-inflammable passenger coaches ever constructed in this country for use on a steam railroad. Each car is mounted upon one motor and one trailer truck, the motor truck being fitted with two 200 horse-power motors driving each axle by means of gears. Both the motor and trailer trucks were thoroughly described and illustrated in this journal in the issue of May, 1906, page 166, and reference should be made to that description for the features of these very interesting all steel trucks.

The car body comes within the classification of " all steel ", since the very slight amount of wood used is for festening a portion of the interior finish, and does not in any way enter into the framing or the structural part of the car. Furthermore, all the inflammable material used has been thoroughly fireproofed, and the wood as in all cases encased in metal, which prevents the possibility of splinters in case of a very improbable collapse of the body. The car measures 48 ft. 11 $^5/_8$ in. in length inside of the body, and is 60 feet in length over the buffers. The height from rail to top of roof is 13 ft. 9 $^1/_2$ in. The width over side sills is 9 ft. 8 $^3/_4$ in.

The original idea whenthisproject was first taken up, was to build a car which could be operated through the subway of the Interborough Rapid Transit Company, connection to which could easily be made at the Grand Central Station, but it was found that such a car would be very restricted in clearance dimensions, and since these cars are operated over divisions up to 40 miles in length, it is necessary to provide more comfort and convenience than such restricted clearances would allow, hence the car built conforms in both clearances and appearance to the standard passenger car of the railroad. It is provided with toilet facilities, good ventilation, and the windows are so constructed that they can be raised to the full height, giving an unobstructed view to a seated passenger. The exterior of the car is painted the standard color, a deep olive green, and lettered and striped in gold to conform to the present passenger equipment. The interior has been painted a dark green relieved by gold and white stripes and light colored head lining.

The wide vestibules have liberal dimensions length-wise, giving an unusually wide side door for the purpose of facilitating the loading and unloading of the car. The doors at the end of the car body are also made unusually wide for the same purpose. These cars will be operated in connection with raised platforms in some cases, and the vestibule trap door of pressed steel has been made to project below the side door, its outer edge being on a line with the side sheathing. Both the side doors and the end door in the car body slide into pockets suitably arranged, and the vestibule end door swings inward and incloses the motorman's control apparatus. A system of levers on the Pitt system permits the opening and closing of the side doors from a point between the cars outside the vestibules. Steps of steel provided with safety treads have been installed for use at stations where raised platforms have not been built.

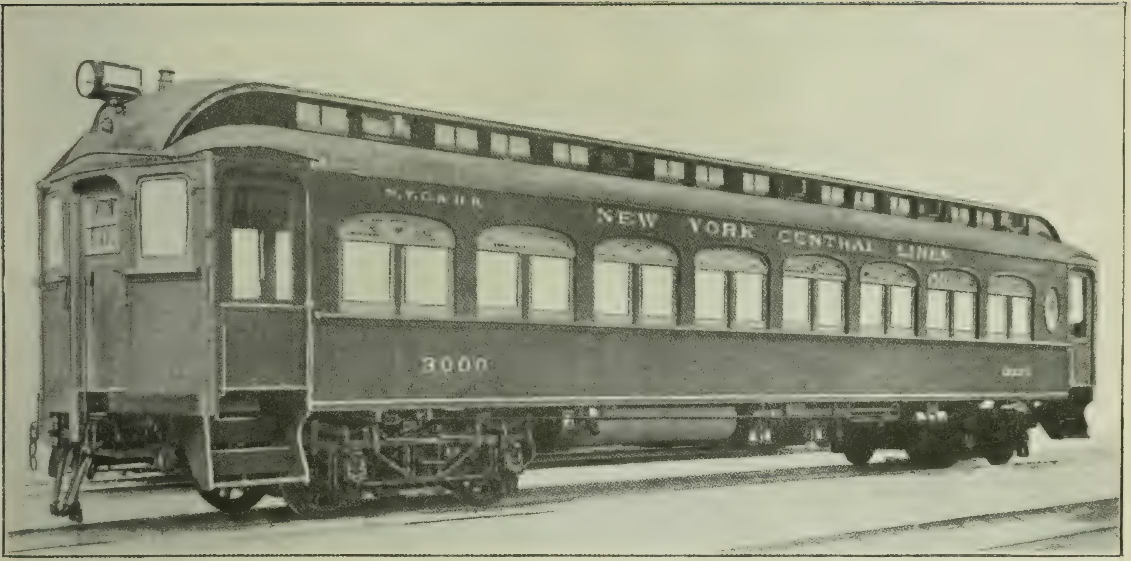


Fig. 13. — Steel passenger car, New York Central & Hudson River Railroad.

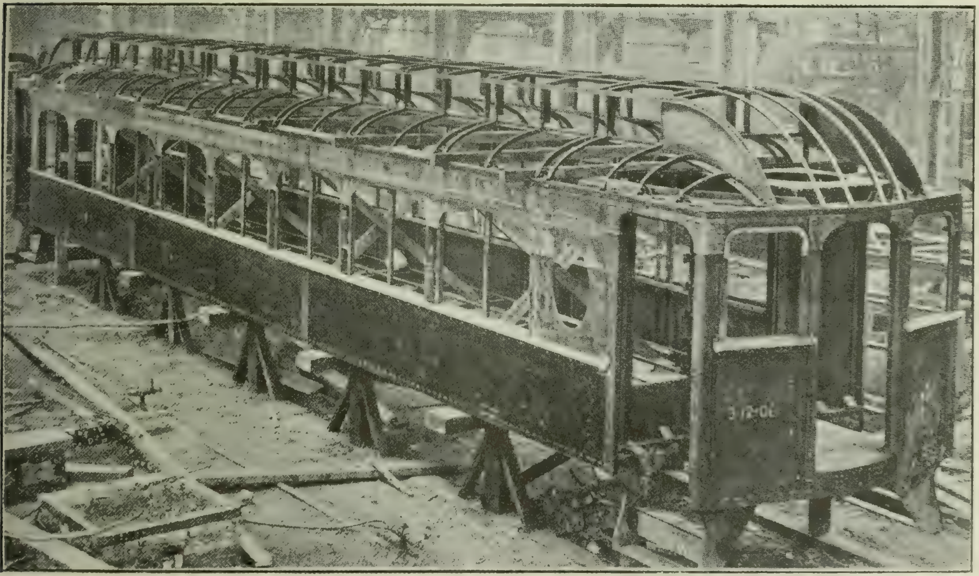


Fig. 14. — View of framing of steel passenger car, New York Central & Hudson River Railroad.

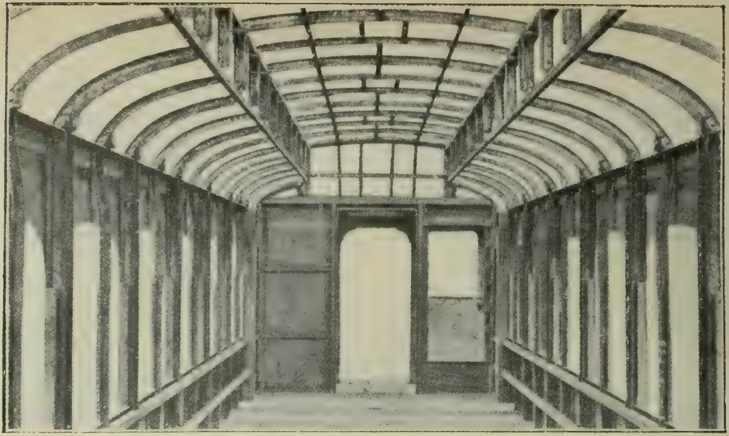


Fig. 15. — View of framing of steel passenger car, New York Central & Hudson River Railroad.

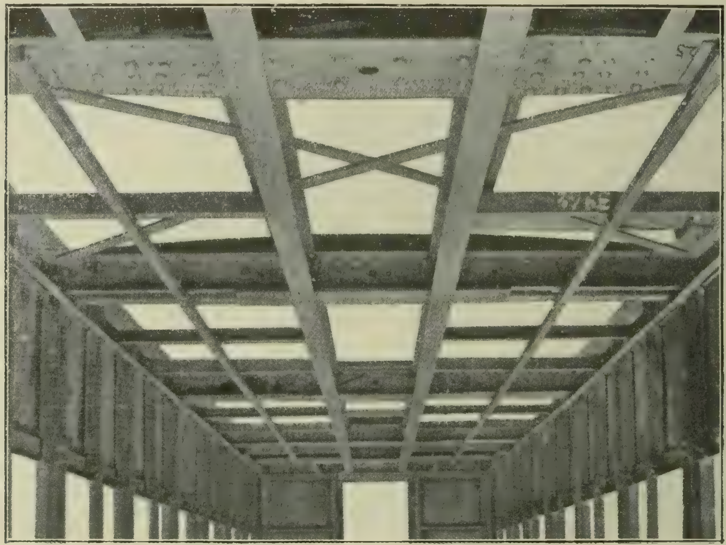


Fig. 16. — View of framing of steel passenger car, New York Central & Hudson River Railroad.

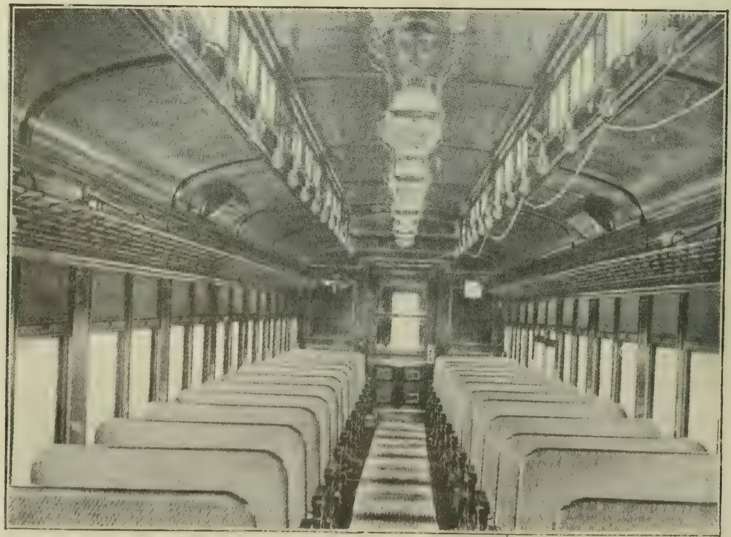


Fig. 17. — View of interior of steel passenger car, New York Central & Hudson River Railroad.

The illustrations show the construction so clearly that little additional description is required. The general scheme of construction is the same as that of the Long Island steel coach designed and built by the same company, which was illustrated in the February issue of this journal, although it should be remembered that this is the earlier of the two designs. This scheme provides for the carrying of the whole load of the car body, including the underframe and the live load, by two plate girders, which form the sides of the car below the window sills. These are made up of a $^3/_{16}$ inch web plate 36 inches deep with a bottom or tension member consisting of a 6 × 6 inch angle which also acts as a side sill of the car. The top or compression member is in two parts, the outer one being a special 4 × 2 $^3/_4$ inch bulb angle and the inner a $^7/_{16}$ × 3 inch bar. The girder is stiffened by the side posts of 3 × 2 inch angles, located in pairs about 34 $^1/_2$ inches apart and riveted to the web plate. These posts are off-set at the top and bottom of the girder to clear its upper and lower members. The web plate is made in three sections, the joint coming at the double 3 × 2 inch angles forming the cripple posts, where the plates are butt jointed and provided with a cover plate with sufficient rivets to make the joint of a strength equal to the solid plate.

The side posts consist, in the case of the double piers, of two 3 × 2 inch angles set 6 inches apart extending from side sill to side plate and off-set as mentioned. In the case of the single posts which separate the two sashes of the double windows, they consist of the cripple posts of two angles set and riveted together and extending from the side sill to the belt rail, above which they are continued by a 2 $^1/_4$ × 2 $^1/_4$ inch T, carried to the side plate, the side plates being 4 $^1/_2$ × 3 inch angles extending the full length of the car.

The carlines consist of 1 $^3/_4$ × 1 $^1/_4$ inch angles in one piece from side plate to side plate, being formed to the proper roof contour. There is a carline at the junction of each single side post, and two set 6 inches apart at the junction of each double post, with the side plate. They are secured to the side plate by flanged corner angles. The carlines are spaced and stiffened by the purlines which consist of short sections of 1 $^1/_2$ × 1 $^1/_2$ inch angles set between the carlines and fastened by corner angles. The body end-carlines are double, being held together by rivets passing through spacing thimbles and the purlines and rafters not being continuous, this allows the removal of the vestibule roof in case of damage without disturbing the main parts of the body frame, the only continuous parts being the side plates and eaves angles. The vestibule roof construction includes two vertical $^1/_8$ inch plates forming the sides of the clere story at this point, which being properly connected and stiffened, assist in carrying the weight of the platform and vestibule. The construction of the roof and vestibule is in its general features similar to that used on the Long Island car mentioned above, and reference can be made to the illustrations in that article for the basic features of this construction.

The underframe consists of two 8 inch 18 lb. I-beams set at 24 inch centres, continuous from buffer beam to buffer beam, which act as centre sills for taking the buffing and pulling strains. The weight of these, however, is transferred to the side girders by means of the cross bearers, and they are not intended to support any of the weight of the car. They are turned out at angle at either end, for the purpose of giving clearance to the radial draft gear. The side sills are the 6 × 6 inch angles mentioned above as forming the lower part of the side girders. Auxiliary longitudinal or platform sills consisting of 8 inch channels extend from the junction of the centre sills and buffing beam back through the end sills and connect to the cast steel bolster. These platform sills, by means of the novel end sill construction and their spécial connection below the flange of the bolster, are fulcrumed in the centre and prevent any sagging of the platform. The cross bearers, of which there are three between bolsters, consist of a trough-shaped pressed steel section passing below the centre sills and continuous between the side sills to which they are securely riveted. Special flanged filling pieces are set vertically at either edge of the trough section, extending between the side and centre sills; also similar pieces between the centre sills. A short cover plate passes through openings in the web of the centre sills and fastens to the top flanges of the filling pieces on either side. Since the filling pieces are also riveted to the sills and the flanges of the trough section the whole construction forms a box girder. The cover plate extends about $^1/_3$ of the distance from the centre toward the side sills, which will allow it to be easily removed without disturbing the side sheathing. The underframing is further tied together and stiffened by two sets of diagonal $^1/_2 \times 2\,^1/_2$ inch bars connecting by gusset plates at the junction of the bolsters and cross bearers with the side sills. There are also diagonal members consisting of pressed steel channels between the ends of the bolsters and the junction of the end and centre sills. The end sills are made up of special flanged filling pieces set in pairs vertically between the centre and side sills and a malleable casting forming part of the draft gear arrangement between the centre sills. A channel which passes continuously below the centre and platform sills is turned up at either end between the flanged filling and riveted to them.

The bolsters are of cast steel of a special I-section design with a broad top. They are arranged to fit around the centre sills and include the centre plate. Lugs are provided for the fastening of the platform sills. Cast steel filling pieces are fitted between the centre sills and above the flange of the side sills and a heavy cover plate passing through the webs of the centre sills and riveted to the outstanding flanges of the bolster is provided. This cover plate is also of such a length that it can be removed without disturbing the side sheating. The bolster is so constructed that it can easily be removed without disturbing the structural part of the car. These bolsters carry practically the whole weight of the car body and its load from the side girders directly to the trucks.

The floor is of " Acandolith " laid on corrugated steel sheets, which are supported by the centre sills and longitudinal floor angles resting on the cross bearers and bolsters. These longitudinal angles are further supported by the floor beams extending from centre to cide sills, equally spaced between the cross bearers. The floor is finished by a tread of narrow wooden strips which are screwed in place and give a secure footing. These run longitudinally in the centre aisle and cross-wise between the seats. As will be noticed in the section of the under frame, there is a clear space of about 4 inches between the floor and the cross bearers, bolsters, etc., which permits the convenient installing of electric wires, air brake piping, etc.

The draft gear is of the National Malleable Casting Company's truck actuated radial design, which will permit the cars to be coupled positively and without difficulty on a 135 feet radius curve. With the arrangement the spring draft gear is placed between the centre sills about 3 feet ahead of the bolster, and from it the draw-bar extends outward and downward, connecting to the coupler, on a level below the centre sills. The draw-bar is pivoted just ahead of the draft gear, and has a connection on either side to the corners of the truck frame; this connection has double ball joints and is fitted with springs and

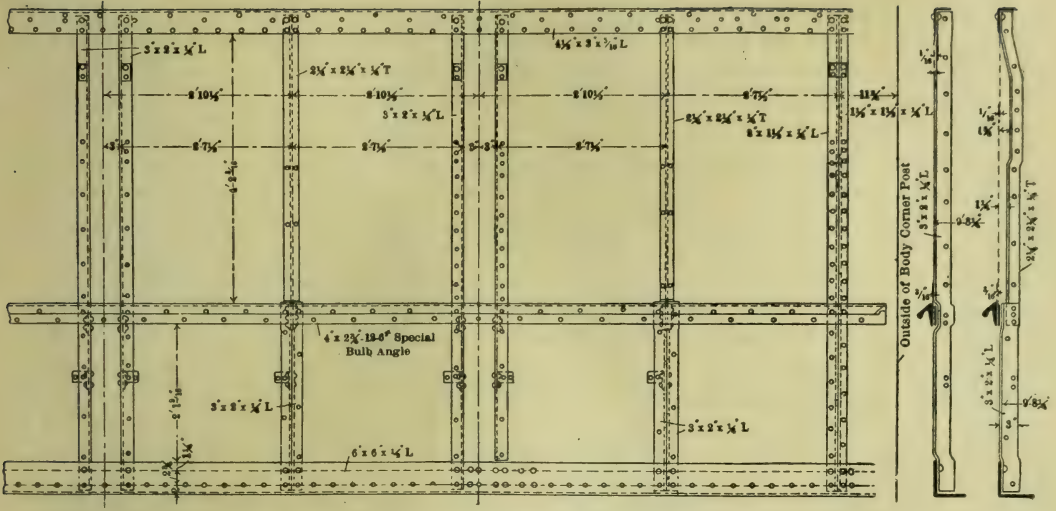
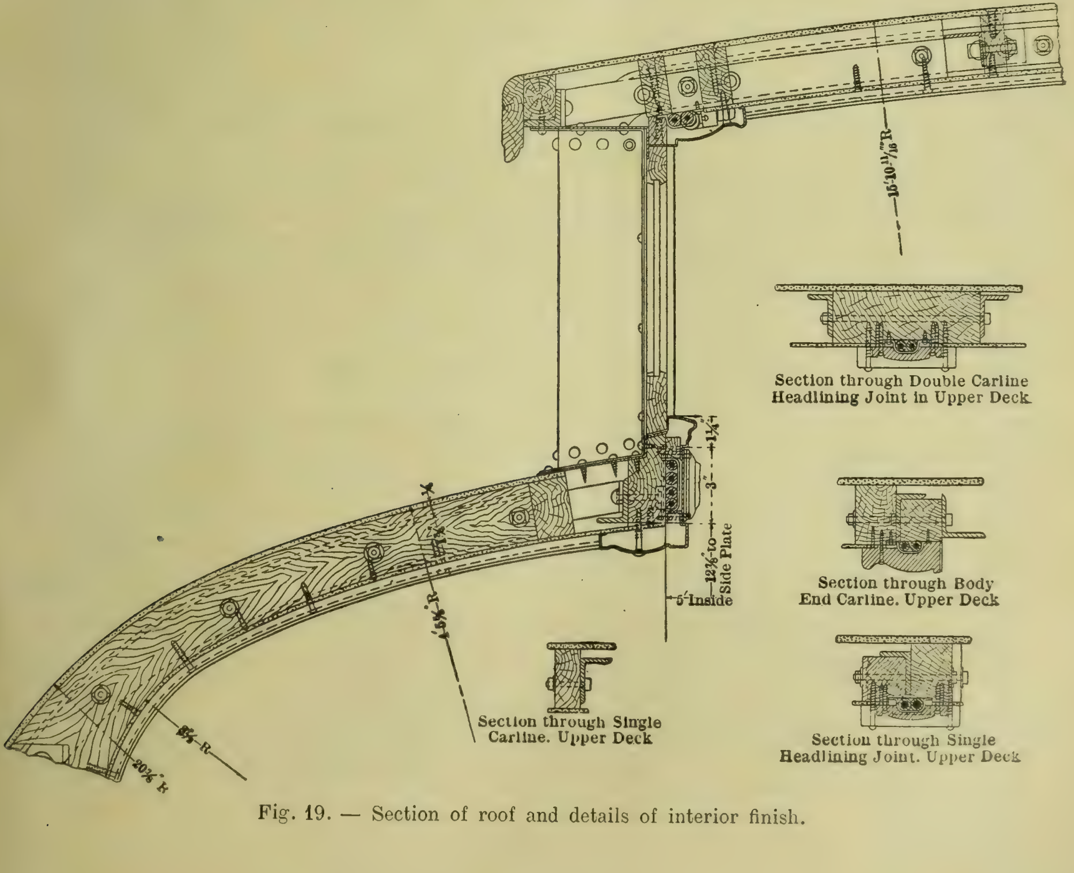


Fig. 18. — Side framing, New York Central steel car.



Section through Double Carline Headlining Joint in Upper Deck

Section through Body End Carline. Upper Deck

Section through Single Carline. Upper Deck

Section through Single Headlining Joint. Upper Deck

Fig. 19. — Section of roof and details of interior finish.

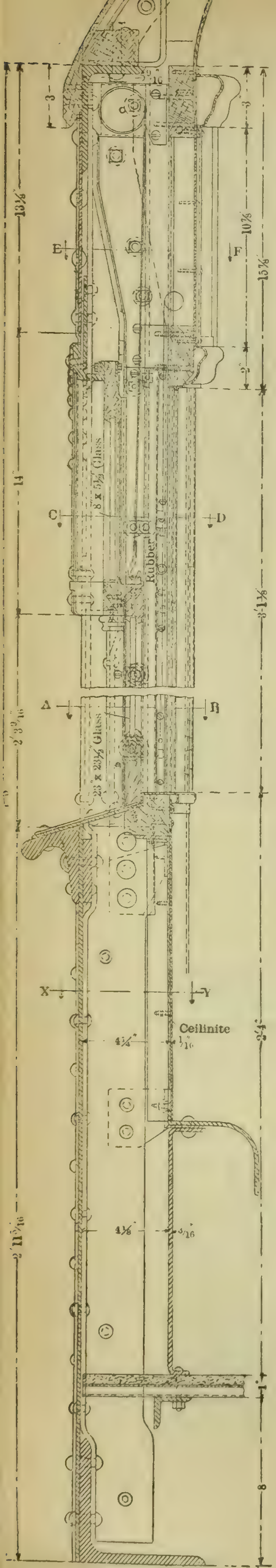


Fig. 20. — Section of side.

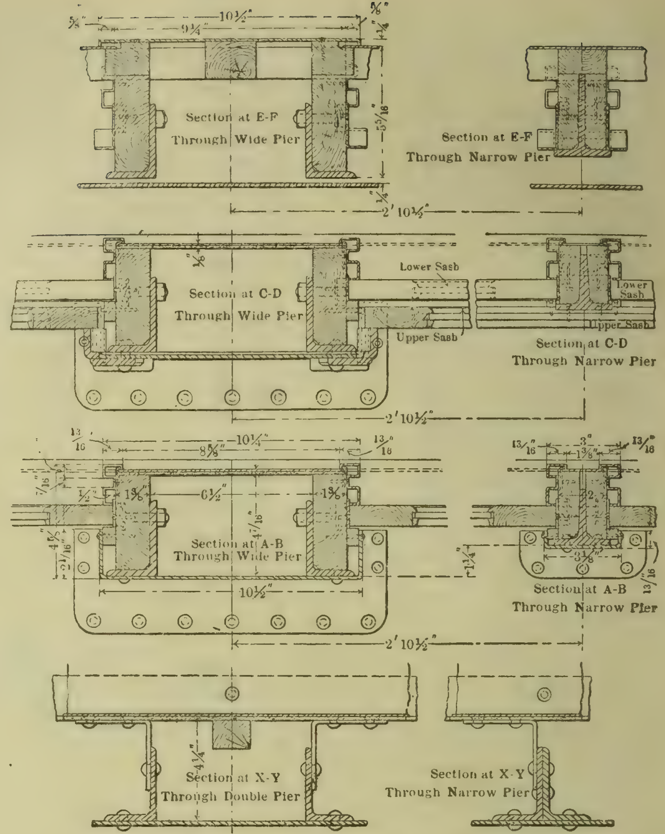


Fig. 21. — Sections of side posts.

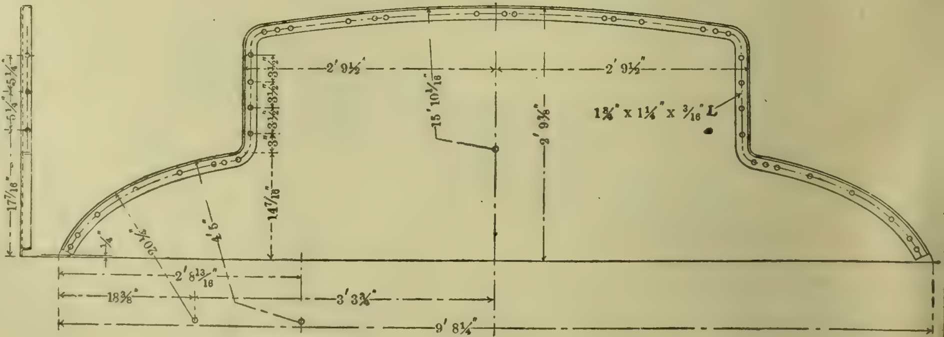


Fig. 22. — Carline. — New York Central steel car.

follower plates in such a manner that as the truck swings, it will carry the draw-bar and coupler with it, always keeping the draw-bar exactly tangent to the curve. However, since the connection is made through springs any slight unusual movement of the coupler will not affect the truck. The air and steam hose are carried from the draw head and take the same movement. The spring buffer is also pivoted and connects to the draw-bar by a cast steel lug set in a pocket, so that it will take the same movement as the coupler and thus the buffing strains after passing the capacity of the spring buffer will be transferred to the draw-bar and thence to the centre sills. The whole arrangement is supported and secured to guides as shown in the detailed illustration.

The interior of the car is finished largely by drawn steel moldings and specially rolled steel plates. The head lining is of " Durite, " which is a special artificial wood, as is also the outside of the roof, in the latter case being covered with painted canvas with copper flashings at the hips and eaves. The seats are of rattan, fireproofed, and fitted to steel frames, being of the " walk-over " type furnished by the Hale & Kilburn Company. The deck windows are of art glass and automatic ventilators to the number of four on either side of the clere-story and two in the saloons have been provided. The car is equipped for both electric and Pintsch gas lighting, and has both electric and steam heating. The Pintsch gas chandeliers are located in the centre of the roof, and the incandescent ligths to the number of thirty along the edge of the deck, in addition to twelve in pairs between the gas lamps. The electric heaters are placed beneath the seats, and the steam heat pipes are placed along the side of the car in the usual manner. This double arrangement of heating and lighting is necessary since the cars will be operated over lines not yet electrified. An electric fan is placed just under the deck in each end of the car.

The motorman's control apparatus, which is located in the ends of the vestibules on the right side, consists of a Sprague General Electric master controller so arranged with a tripping device, that if the motorman's hand leaves the handle the controller will spring to the off-position, and at the same time give an emergency application of the brakes. This controller is situated for operation by the motorman's left hand and can be locked when not in use. Directly in front of the motorman, is the engineer's valve of the quick service Westinghouse brake system. He also has conveniently located a cord leading to an air whistle, and just behind him in the end bulkhead of the car, is arranged a switchboard containing all of the switches and fuses necessary for operation from that end. This is closed and locked by a steel door. Each car is provided with an electric head light at either end located on the roof.

It will be noticed that there is an extension platform at the ends of the car outside of the vestibule, which has been installed simply as a gangplank between the cars, made necessary by the large overhang of the radial coupler, which in turn is demanded by the shar curves on which the car will be operated in the Grand Central Station.

The cars weighs 105,500 lb. total, in running order. Of this, the body of the car weighs 59,860 lb. without electrical equipment and 67,200 lb. with electrical equipment. The motor truck weighs 15,000 lb. and the trailer truck 11,140 lb., the weight of the motors alone being 12,160 lb. for two, thus the car with one motor and one trailer truck but without motors or the electrical apparatus on the body, would weigh 86,000 lb. or about 1,344 lb. per seated passenger, which compares very favorably with a modern substantially constructed wooden passenger coach.

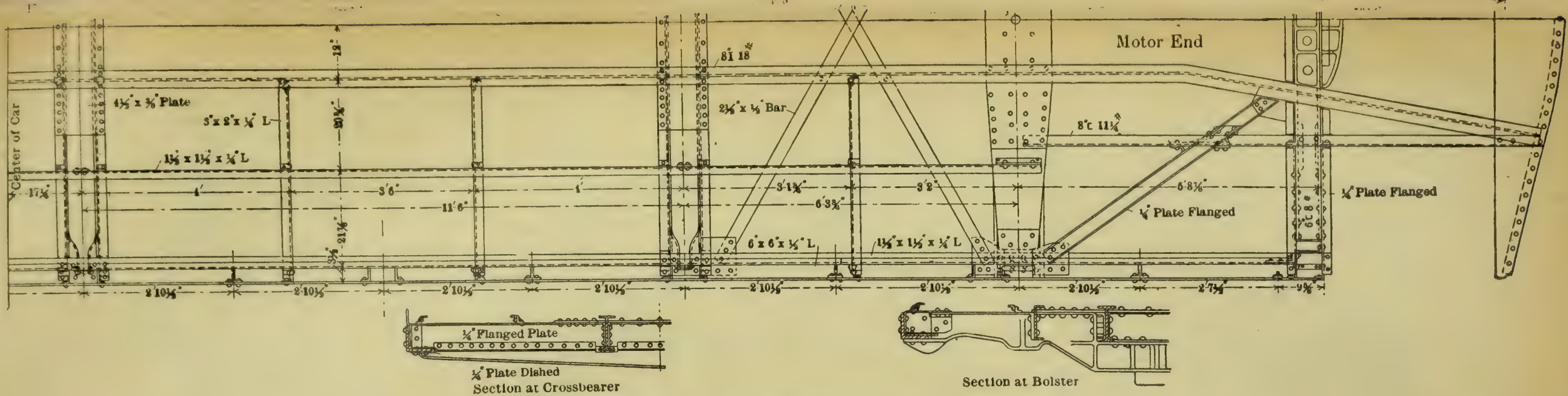


Fig. 23. — Underframe. — New York Central steel passenger car.

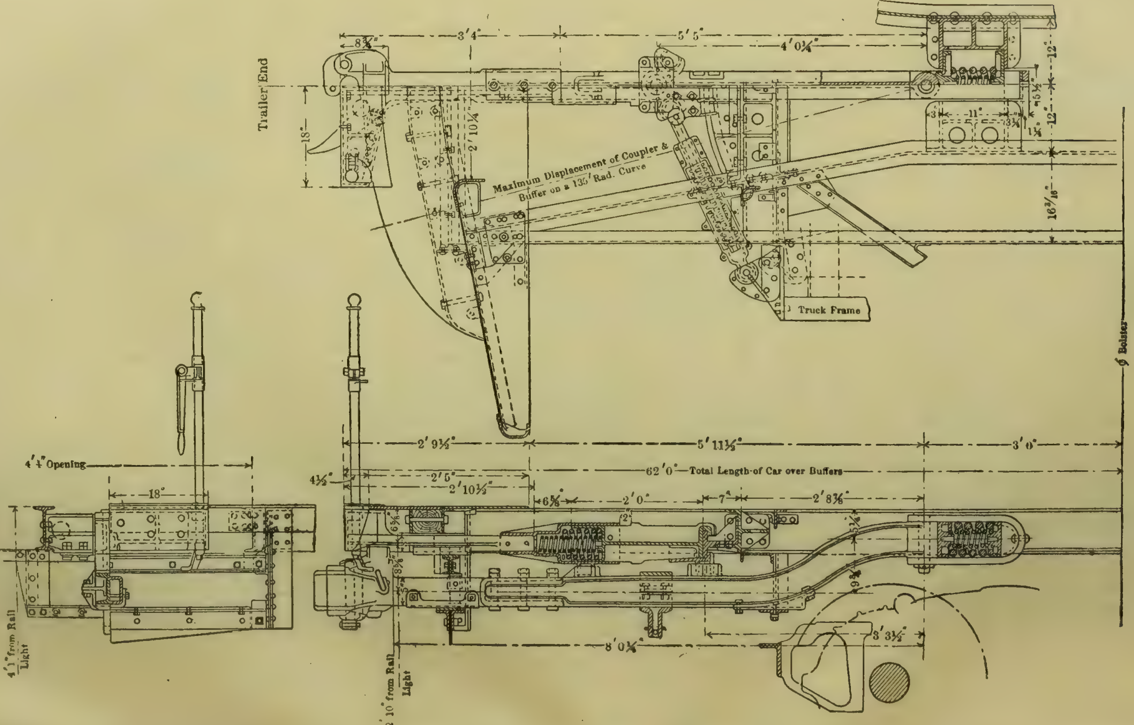


Fig. 24. — Truck actuated radial draft gear. — New York Central steel car.

The specialities in the car not previously mentioned are as follows : The Safety Car Heating & Lighting Company's Pintsch gas lighting, Gold Car Heating & Lighting Company's steam heat, Consolidated Railway Electric Light & Equipment Company's electric heaters. The hardware from Adams & Westlake Company McCarthy continuous basket racks, Rostand Manufacturing Company. The steel mouldings, Dahlstrom Metallic Door Company. The sash balances, National Lock Washer Company. Tower couplers, National Malleable Castings Company. Automatic ventilators, Automatic Ventilator Company. Safety treads, American-Mason Safety Tread Company. Door operating devices, Pitt Car Door Company. Curtains, Curtain Supply Company. The roof covering and head lining of " Durite," Indestructible Fibre Company. The " Celinite " for insulating the interior finishing, H. W. Johns-Manville Company. Signal lamps and brackets, Dressel Railway Lamp Works and thermometers, Parker Manufacturing Company.

The general dimensions are as follows :

Length over buffers	60 feet.
— inside body	48 ft. 11 $^{5}/_{8}$ in.
Width over side sills	9 ft. 8 $^{1}/_{4}$ in.
Height, rail to top of roof	13 ft. 9 $^{1}/_{2}$ in.
Total weight in running order	105,500 lb.
Weight of body	67,170 lb.
— — without electric equipment	59,860 lb.
Weight of trucks :	
Motor truck	15,000 lb.
Trailer truck	11,140 lb.
Weight of motor and number per car	12,160 lb. for two.
— of electrical apparatus without motors, included in body	7,340 lb.
Seating capacity	64 passengers.
Number of saloons or toilet rooms	2.

Type of truck : Four-wheel motor truck, motor truck wheel base 7 feet, 36-inch wheels; trailer truck wheel base 6 feet and 33-inch wheels.

[621 .133.4]

3. — Smoke prevention apparatus for locomotives (Staby system).

Figs. 25 to 32, pp. 752 to 754.

(*The Railway Gazette.*)

When, as often happens in this country, railway companies are summoned to answer at the courts, to a charge of " permitting dense smoke to arise from the chimney of a locomotive " while the latter is standing in the vicinity of house or other property adjoining the line, the issue generally turns upon the point as to whether " reasonable care " was taken by the defendant company to prevent the nuisance, and it has not infrequently been suggested by learned magistrates, in giving judgment, usually against the railway, that suitable apparatus should be devised for overcoming the tendency which locomotives have to emit smoke from the chimney when stationary.

We have recently received particulars of an apparatus, designed for the purpose of smoke prevention and applicable to locomotives, which is giving very successful results on the Bavarian and other State railways of the European Continent. The apparatus, which is described as being constructed on the Staby system, after the name of its inventor, is manufactured by Messrs. Koerting Brothers of Körtingsdorf near Hannover.

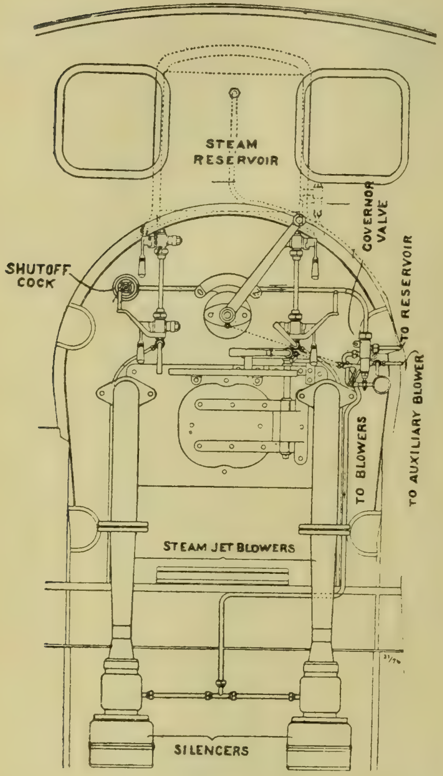


Fig. 25.

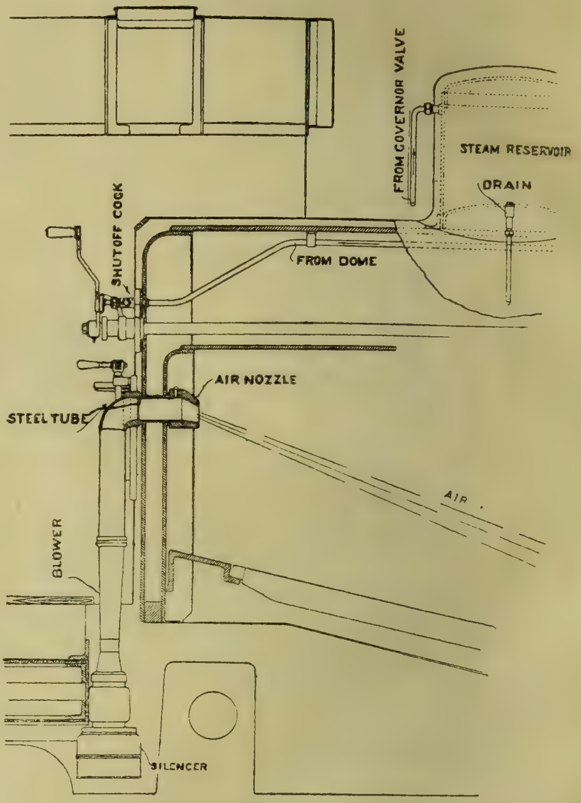


Fig. 26.

Immediately subsequent to firing a locomotive, and when the furnace doors are closed, dense black smoke arises from the chimney for a short time, the reason for this being that the quantity of air entering the fire-box through the grate is insufficient to effect complete combustion of the gases from the fuel and the air does not become mixed with the gases with sufficient intimacy. Usually, also, when the regulator is shut off, dense smoke is given off, because when the blast pipe ceases working, the weak natural draught is insufficient to draw the necessary air through the grate.

In order to prevent smoke formation, a quantity of air, proportionate to the amount of fuel to be gasified should be supplied, and it is on this principle that the apparatus is designed. The air required is blown into the fire-box by means of two steam jet blowers, steam for which is taken from a special reservoir of definite capacity. The reservoir is

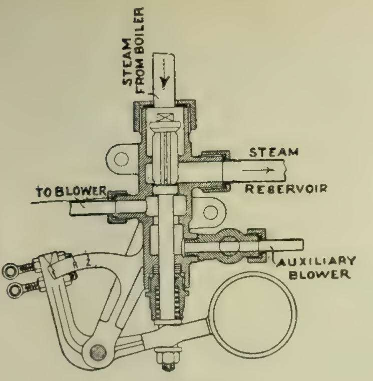


Fig. 27.
Valve opened by fire door.

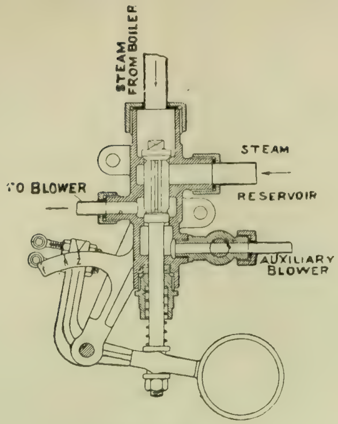


Fig. 28.
Valve closed.

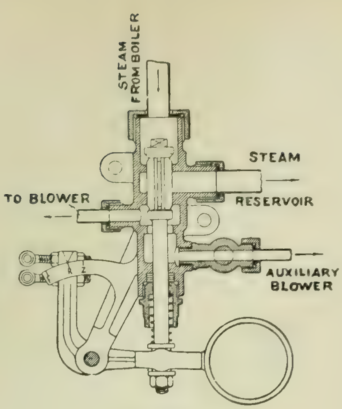


Fig. 29.
Valve opened by regulator lever.

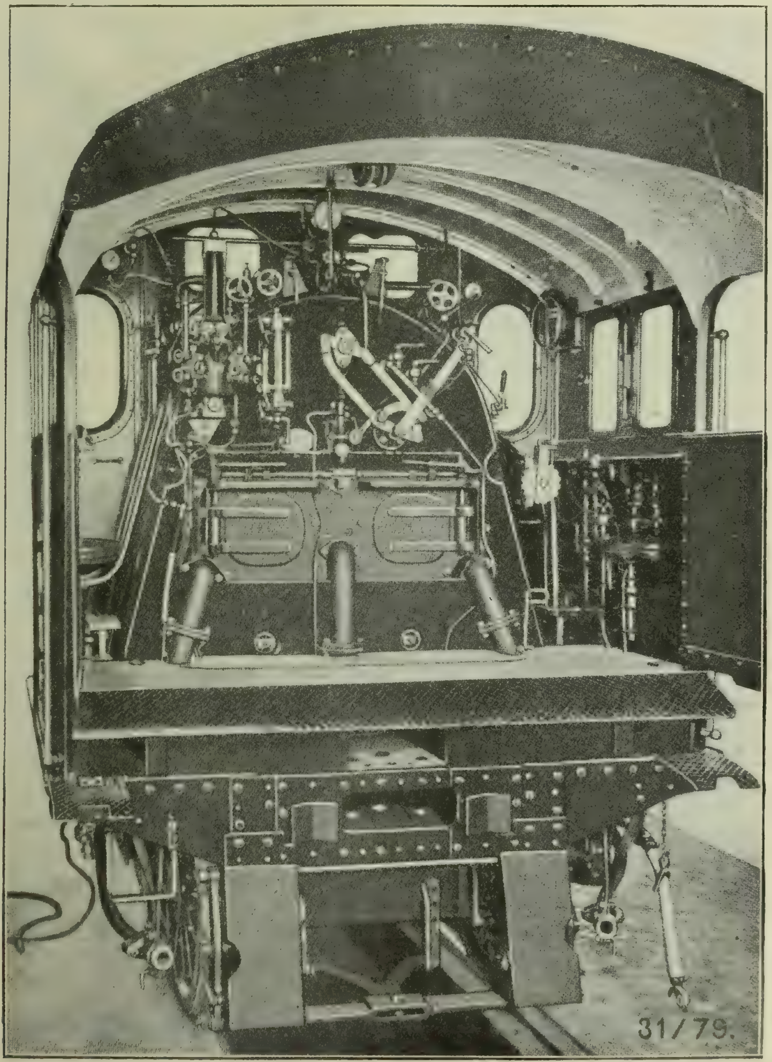


Fig. 30. — General view of cab of locomotive fitted with smoke prevention apparatus.

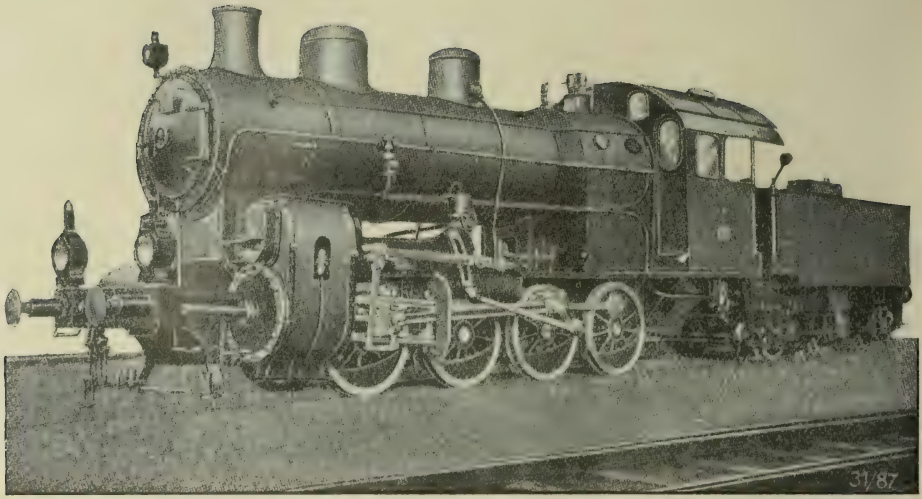


Fig. 31. — 0-8-0 type locomotive fitted with Staby system smoke prevention apparatus.

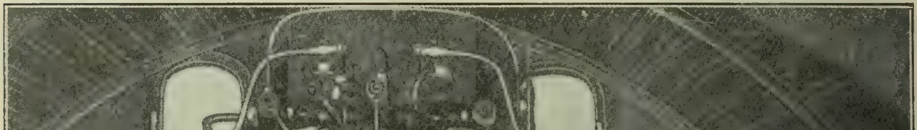


Fig. 32. — View showing upper portion of fire-box end with valves and piping.

charged with steam to an extent depending upon the movement of the fire-doors and the regulator lever. The arrangement consists of a stop valve and a control valve, a reservoir with automatic valve for draining the water of condensation, two jet steam blowers with silencers, two air pipes, two steel pipes through the inner and outer shells of the fire-box, two air nozzles and the necessary connecting pipes.

In operating the apparatus, the stop valve is first opened and the steam, which should be taken from the dome to ensure its being as dry as possible, is then led to the control valve, which latter is closed. If, after this has been done, the fire-door is opened for firing, the chain attached to the door moves the vertical arm of the bell crank lever (fig. 25) to the left, so that the pointer is over F (fig. 27). The valve is thus completely opened, and steam from the boiler is admitted to the reservoir, while, at the same time, the passage from the valve to the steam jet blowers and also the auxiliary blower are closed. As soon as the fire-door is shut, the control valve returns automatically to its closed position by reason of its weight. The steam receiver is now in communication with the steam jet blowers, while the auxiliary blower is closed (*see* fig. 28).

The steam is led from the receiver to the two blowers by means of a branch pipe, and air is drawn through the silencers and blown through the air nozzles in wide thin jets of high velocity from the fire-box.

The rising gases of combustion are this intimately mixed wtih air and perfect combustion is attained before they can become decomposed by contact with relatively cold fire-tubes. As the pressure of steam in the receiver decreases, so does the quantity of air blown in, and after a certain period has elapsed, the steam is entirely used up, the blowers then ceasing to work.

The automatic valve on the reservoir closes, as soon as the steam pressure has risen to between $^1/_4$ and $^1/_2$ atmosphere and opens again to discharge the water of condensation as soon as the pressure has again fallen to this figure. The area of the pipe between the control valve and the receiver is such that the latter is only fully charged at the boiler pressure if the fire-door, and therefore the control valve, is open for a period corresponding to that required for normal firing. If the door is open for a shorter time as required for a small charge of fuel, the pressure in the receiver is below that of the boiler, and the time of discharge of steam, and therefore, the action of the blowers is reduced. The air introduced by the blowers is varied automatically to suit the amount of the fuel charge.

When the regulator is closed, the control valve is opened by the chain (fig. 25), to the extent of half its full opening. Boiler steam is then admitted to the receiver, the steam jet blowers and the auxiliary blower. With the regulator permanently closed, a certain quantity of air is supplied, and the fire is also urged by means of the auxiliary blower. The latter may be shut off during log stops at stations or when the boiler pressure rises too high by shutting off the stopcock on the control valve.

After the regulator is again opened, the control valve is closed and the steam remaining in the receiver maintains the steam jet blowers in action while the engine is leaving the station so that the production of smoke is checked. By the adoption of this arrangement the gases are thoroughly burned and the heating value of the fuel is effectually utilised and economy is realised.

By means of the current of air blown into the fire-box, the whirling particles of coal are prevented from going through the fire-tubes and into the smoke-box. The surface of the tubes is thus cleaner and evaporation is improved. The steam consumption is very small, amounting at each period of firing to about 0·5 kilogram. The steam used during stops can generally be neglected as there is usually considerable excess of steam, which in the ordinary way is blown off at the safety valves.

The arrangement is entirely automatic, and requires no attention on the part of the driver or stoker. The only manipulation is confined to opening the stop valve at the beginning and closing it at the end of a run. The noise of the blowers is hardly noticeable if the air is made to pass through suitable silencers.

There are only two movable parts, *viz.*, the stop valve and the control valve, so that the maintenance cost is very low. The air nozzles in the fire-box are of hard dense steel, and as they are continuously cooled by the in-drawn air, they have a long life. The steel pipe, between the inner and outer shell of the fire-box, is protected from burning by a copper ring at one end and by the air nozzles at the other. The arrangement can be easily and quickly fitted to existing as well as new locomotives, without interfering with the original construction.

The advantages claimed for the apparatus are briefly as follows :

1° Simplicity of construction ;
2° Controlled action ;
3° Completely automatic ;
4° Economical in steam comsumption ;
5° No attention required from driver or fireman ;
6° Low first cost and maintenance.

The manufacturers, Messrs. Koerting Brothers, inform us that they are receiving a large number of inquiries relating to the apparatus from the principal German railway administrations, and others.

[625 .253]

4. — The M triple valve.

Figs. 33 to 40, pp. 758 and 759.

(*Railway and Locomotive Engineering.*)

As the electrification of steam roads proceeds, it is found necessary to modify in some important particular the air brake apparatus, to make it meet the requirements in a highly satisfactory manner. Thus, in the electrification of the Rochester branch of the Erie Railroad, it was found that the M triple valve illustrated herewith, would best meet the requirements of the service of this branch. This triple, as may be seen from figure 33, is of the pipeless variety, that is, it bolts to a bracket located in some convenient place in the car and to this bracket all the pipe connections are made, so that when it is necessary to remove the triple for cleaning and repairs, these connections do not have to be disturbed.

The M triple valve is of the plain type, similar to the F1 or the H24 plain triple, and it performs all of their functions. In addition, it has the quick re-charge of auxiliaries, the quick service application of the brakes, the graduated release of cylinder pressure, and the high pressure emergency features. Because of possessing these additional features, it is a triple that is especially adapted to high speed passenger service where the trains do not consist of more than five cars.

A longitudinal and a cross section view of the M triple is shown in figures 34. This view gives us a clear idea of the internal construction, showing besides the familiar piston, slide valve and graduating spring, a graduating valve of the slide valve pattern, mounted on the main slide valve; a high pressure emergency feature, consisting of a piston and a check valve and spring, placed on top, and cross wise, of the body of the triple; and the quick re-charge features which consists of a check valve spring located in the lower part of the valve body, and a control pipe or reservoir connection.

A face view of the graduating valve, a face and plan view of the slide valve, and a view of the slide valve seatare shown in figures 35.

For the purpose of making clear the operation of the M triple, use is made of the diagrammatic drawings, figures 36, 37, 38, 39 and 40.

The release position of the internal parts is represented in figure 36. Air from the brake pipe enters the triple through the passages marked *a*, *c*, and *g*, and it passes into chamber *h*, thence through the feed groove *i* into chamber R and the auxiliary reservoir. Brake pipe air also flows upward from passage a past the small check valve through ports *y*, *j* and *u* into chamber R and the auxiliary reservoir.

With the M triple, there is used a control pipe or a control reservoir, whichever is deemed preferable, and it has a connection to the M triple at port *x*, so that, at the same time, air is passing through ports *a*, *c* and *g* and also past the small check valve through ports *y*, *j* and *u*, to chamber R from the control pipe or the reservoir, as the case may be, is flowing through passage *x* and port *k* to chamber R and the auxiliary reservoir. Hence it will be seen that with air flowing through these three channels to the auxiliary reservoir, the latter will be quickly charged to maximum pressure after each release of the brake.

The service application position is representation in figure 37. The brake pipe and the auxiliary reservoir being charged to standard pressure in the manner just described, a service reduction in brake pipe pressure causes the triple piston, the slide and the graduating valves to assume the position shown. The main slide valve closes the brake cylinder exhaust, port M, also the charging ports *k* and *j*, and cuts off the control *i* pipe from the auxiliary. The triple piston cuts off the charging port *i* and the small check valve prevents the back flow of air through port *y*. The graduating valve uncovers ports *z* and *r* and auxiliary reservoir air flows through these ports to the brake cylinder; at the same time, brake pipe pressure raises the check valve and allows brake pipe air to flow through port *y* into cavity *v* in the graduating valve, thence through ports *q* and *r* to the brake cylinder, thus producing the quick service feature and economizing in the quantity of air used in make the brake application. This local venting of brake pipe air into the brake cylinder, also causes a quick response of all the other triples in the train. The service lap position is represented in figure 38. As soon as auxiliary reservoir pressure reduces slightly below brake pipe pressure, the triple piston and the graduating valve move to the position shown, closing all ports between the brake pipe and the auxiliary, and between the brake pipe and the brake cylinder, so that the brake is held applied without increase or without decrease in cylinder pressure.

The graduated release lap position is represented in figure 39. If only sufficient air is

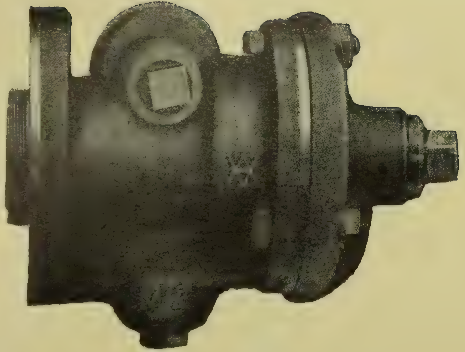


Fig. 33. — The M triple valve.

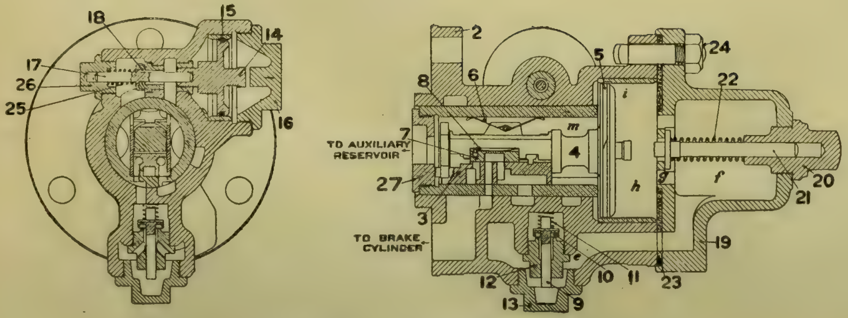
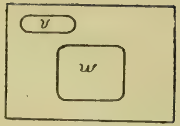
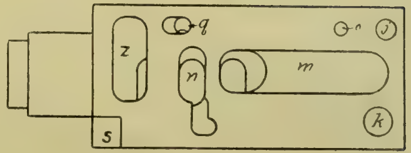


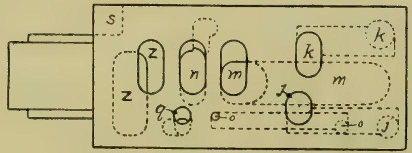
Fig. 34. — Longitudinal and cross section of M triple valve.



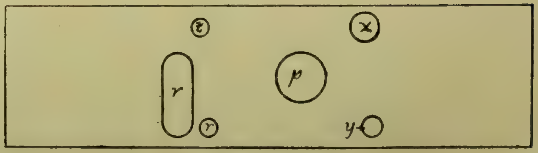
Face view.
Graduating valve.



Face view.



Plan view.
Slide valve.



Slide valve seat.

Fig. 35. — Diagrams of the valve and seats M triple.

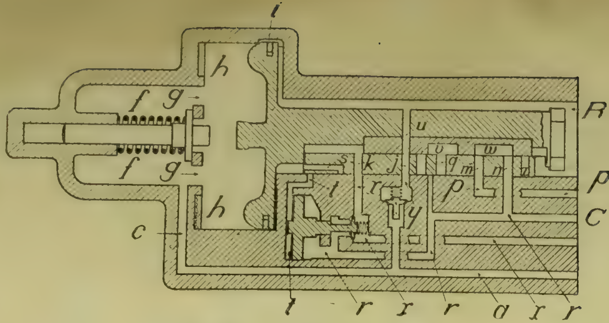


Fig. 36. — Release position.

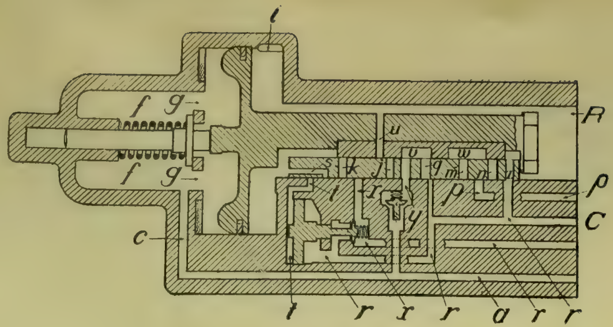


Fig. 37. — Service position.

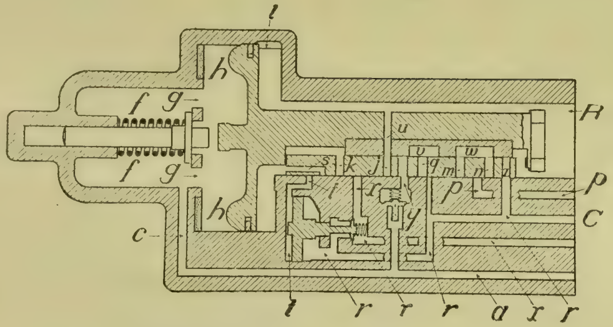


Fig. 38. — Service lap position.

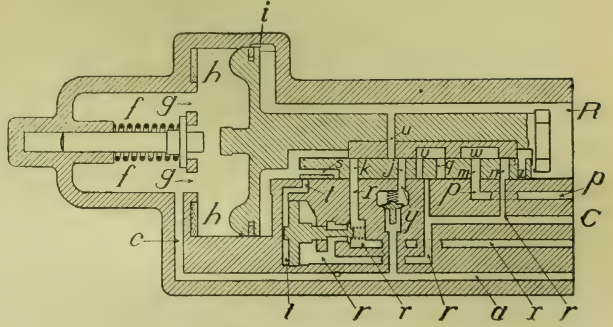


Fig. 39. — Graduated-release lap position.

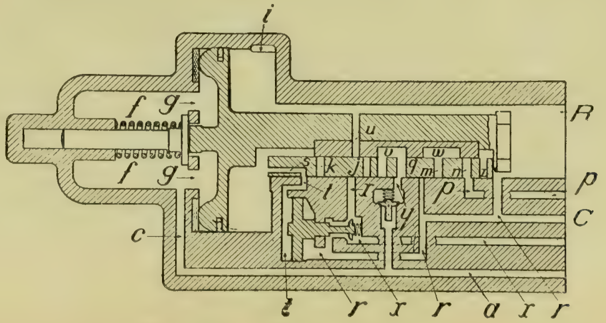


Fig. 40. — Emergency position.

thrown into the brake pipe to raise the pressure high enough to move the piston slide and graduating valves to release position (*see* fig. 36) and then the brake valve handle is lapped, cutting off the supply of air to the brake pipe, the inflowing air from the control pipe through ports *x* and *k* to the auxiliary reservoir will raise the pressure in the latter slightly above that in the brake pipe; and then the piston and the slide valves will move to the position shown, closing all ports in the triple and retaining a portion of the brake cylinder pressure. The graduated release operation may be repeated until both the brake pipe and the auxiliary reservoir are charged nearly to maximum pressure. When a control reservoir instead of a control pipe is employed, the connection to the triple valve is made at port *x* as already stated, and all of the air passing into the control reservoir and into the auxiliary reservoir in charging, is taken from the brake pipe through the feed groove *i* and ports *y*, *j* and *u* into the auxiliary reservoir, thence through ports *k* and *x* into the control reservoir, which is, in this manner, charged to the same pressure as the auxiliary. The passage between the auxiliary and the control reservoir is open only when the triple is in release position. The emergency position is shown in figure 40. When the brake pipe reduction is heavy and quick, the auxiliary pressure forces the triple piston to the extreme left, placing the slide and graduating valves in the position shown. Auxiliary reservoir air then flows past the end of the slide valve through port *r* into the brake cylinder. At the same time, the auxiliary air is flowing through port *r* it also flows through ports *s* and *t*, and it forces the by-pass piston to the right. This operation opens the by-pass valve and the air from the control pipe is admitted through ports *x*, *x*, past the by-pass valve through ports *r*, *r*, into the brake cylinder. When the brake cylinder and auxiliary reservoir pressure become equal, air continues to flow from the control pipe to both the auxiliary and the brake cylinder through port *r*. When the auxiliary, the brake cylinder and the control pipe pressure are nearly equal, the by-pass valve will close and the by-pass piston will return to its normal position. The opening of the by-pass valve in emergency applications, gives a much higheé cylinder pressure than is obtainable with the standard quick action triple valve.

[625 .14 (01]

5. — An experimental railway track for testing purposes.

(*The Railway Age*)

There is abundant evidence in the records of recent accidents to show that railroad track in the United States is not equal to the requirements imposed by heavy rolling stock and high speeds. During the winter we have had numerous derailments because of spreading rails, broken rails and various defects of roadway. Several of the worst accidents have demonstrated that track on curves as now constructed will not stand up under heavy trains at high speeds.

Increasing speed until the track gives way, destroying whole trains of expensive Pullman cars and causing the death of scores of passengers, is an expensive way to ascertain the weak points of the track. While it is a difficult matter to measure the strength of track, some way should be devised to ascertain the limit of its safe resistance besides that of using high-speed trains driven to their destruction.

The American Railway Engineering and Maintenance of Way Association represents the particular department of railway organization which is most vitally interested in this matter, and it is encouraging to find that one of the papers prepared for that association deals directly with the problems involved. " The study of the stresses in track superstructure and rational design based thereon, " by O. E. Selby, introduces the most important subject which could occupy the attention of maintenance of way engineers, and it should bring out an interesting discussion. What will be said in reply to Mr. Selby's statement that " the growth of railroad track with heavier loads has been entirely along empirical lines and not one single detail of track superstructure bears the marks of engineering design ? "

The track is a complex structure carrying the same heavy and destructive loads as bridges and hence deserves the same careful design; it seems proper to examine the unit stresses existing under present conditions, and it is possible to limit these stresses to those proper for a permanent and more durable structure. Mr. Berry finds that with a 50,000-pound axle load and 100 per cent impact, the extreme fiber stress on the 80-pound rail with a section modulus of 10 is 18,750 pounds, which is very high for Bessemer steel subject to sudden blows.

The extreme fiber stress in ties is found to be 1,920 pounds per square inch, and the bearing on ballast 5 tons per square foot and on superstructure 3·6 tons per square foot. All these are far in excess of what would be considered safe or good practice in a bridge structure, and this accounts for broken rails, cut rail seats, broken ties, loose and pulverized ballast. This causes a heavy and constant maintenance expense which is being paid, in order to save the first cost of a better structure. The author suggests a specification under which this better structure may be obtained and recommends that the fiber stress on the rail should not exceed 15,000 pounds, and that the section modulus be 20, which is 37 per cent greater than that of the 100-pound rail; this would require a 115-pound rail with 6-inch base and 7 inches in height. The bearing on tie would be protected by a plate 6 $^1/_4$ by 8 inches. The ties should be at least 9 inches on the face and spaced 20 inches on centers and the bearing on ballast reduced to 3·8 tons per square foot. For axle loads of 60,000 pounds, the depth of ballast should be 20 inches and the width of roadbed 24 feet.

While accurate mathematical calculations relating to the strength of railroad track are not possible, yet investigations of this kind show the weak points of the present superstructure and suggest the methods of improving it. What is needed is accurate measurements of deflections, both vertically and laterally, under heavy rolling equipment, especially on curves, and from these more accurate determinations of actual stress may be obtained. There should be more testing of track material, while in the track under regular service, and this suggests the idea of having an experimental railway track for testing purposes. Something of this kind has recently been established in Germany. The State railway administration has obtained a tract of land near Berlin where it has built an experimental railway for testing purposes; the tests will include those on superstructure, rails, joints, ties, spikes and ballast (1). On this will be operated different kinds of rolling stock at various speeds. For high-speed work which may be considered dangerous, electric locomotives will be used, and the trains operated without a motorman by simply regulating the potential of the current, and no personal danger is involved.

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(1) Vide *Bulletin of the Railway Congress*, No. 8, August, 1907, p. 1340.

Even with the light locomotives and cars, German engineers are not satisfied with the design and construction of their present track, and they believe there is more uncertainty in regard to the strength of track than any other structure connected with railroads. For this reason, they have established the experimental testing track. With our heavier loads and the constant tendency to even higher speeds, how much greater is the necessity for similar work by railroad engineers in the United States? A special testing laboratory for the details of rolling stock has often been proposed and a report on the subject giving a plan for the organization, the kind of work to be done and the cost of equipment and operation is to be found in the proceedings of the American Railway Master Mechanics' Association for 1899. A resolution was adopted in favour of establishing such a laboratory to be conducted under the direction of the association, but the various testing machines for railway equipment which were developed by the mechanical association, were gradually collected at Purdue University. Tests are there conducted on the friction and durability of brake-shoes, on air brakes, triple valves, car couplers and brake-beams, and various investigations have been made for the railroads on questions connected with the operation of locomotives, which have proved of immense value to the railroads and have materially assisted the associations in establishing standards. The University of Illinois has established an engineering experimental station where a beginning has been made in testing railway material, notably those on the holding power of spikes, and on reinforced concrete. Why should not the honors be divided and Purdue conduct testing and research work relating to rolling stock, while the University of Illinois could give special attention to testing track and roadway metarial? This would have to be a testing track where many of the uncertainties relating to unit stresses in track could be eliminated by actual measurements of deflections, and work similar to the German testing track could be conducted. Such experimental work could be carried on by the university, most of it by students as a part of their laboratory course in railroad engineering, and it should be under the general direction of the American Railway Engineering and Maintenance of Way Association.

[656 .28 (01 (.42)]

6. — British practice in railroad accident inquiries and railroad inspection,

By Lieutenant-Colonel H. A. YORKE,

CHIEF INSPECTOR.

(*Railroad Gazette.*)

The Regulation of Railroads Act, 1842 (¹), renders it obligatory upon every railroad company to give notice to the Board of Trade of its intention to open for passenger traffic any railroad or section of a railroad. This provision has no reference to lines used wholly for goods traffic. On receipt of such notice, the Board of Trade is required to cause the

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(¹) An earlier Act of 1840 contained similar, but less complete, provisions, and inspections of railroads prior to 1842, and inquiries into accident prior to 1841, were held under the Act of 1840. The earliest recorded inspection took place in November, 1840, and the earliest recorded inquiry into a railroad accident was made in August, 1840.

line to be inspected before the opening takes place. If the officer appointed by the Board should after inspection report to the department that in his opinion "the opening of the line would be attended with danger to the public using the same, by reason of the incompleteness of the works or permanent way, or of the insufficiency of the establishment for working such railroad," the department may direct the company to postpone the opening of the line for one month at a time, the process being repeated from month to month as often as may be necessary. The company is liable to a fine of £20 a day if it should open a railroad in contravention of such order. The inspections made by the officers of the Board of Trade are very complete, the permanent way, bridges, viaducts, tunnels, stations and other works are carefully examined, iron and steel girders are tested, and the signalling and interlocking are thoroughly tried, and every means is employed to ascertain that the railroad has been constructed and completed in the most satisfactory manner. A simple code of requirements has been prepared by the department for the guidance of railroad companies, and as the special circumstances of each line are considered on their merits, it does not often happen that it becomes necessary to postpone the opening of a new line. The Act does not authorize the department to inspect any railroad, or part of a railroad, after it has been opened, unless some alteration or addition is made to it, such as the construction of an additional line, deviation line, station, junction, or crossing on the level, in which case the new works are required to be inspected. It is the duty of the company to maintain the line in accordance with the standard of efficiency which it originally possessed, but whether it does so or not the Board of Trade has no power to interfere. It may be of interest to state here that all tramways or street railroads, or any extension of them, whether worked by horses, steam, cable, or electricity, have also to be inspected for the Board of Trade and "certified as fit for traffic" before they may be opened for public use.

The Regulation of Railroads Act of 1871 renders it obligatory on all railroad companies to give notice to the department of any accident which may occur in or about the railroad, or any works or buildings connected therewith, that is to say, any accident attended with loss of life or personal injury to any person whatsoever, any collision in which one of the trains is a passenger train, any passenger train or part of such train leaving the rails, or any other accident likely to have caused loss of life or personal injury, specified on that behalf by any order made from time to time by the Board of Trade. On receipt of such report, the department is authorized to cause an inquiry to be made into the cause of any accident so reported, and the officer appointed to hold the inquiry has power to enter upon any railroad premises for the purpose of his inquiry, to summon any person engaged upon the railroad to attend the inquiry as a witness, and to require the production of all books and documents which he considers necessary for the purpose. There is no statuory procedure laid down for such inquiries, which are conducted in the manner that seems to the officer best suited to the circumstances of the case, but a fairly well recognized procedure has grown up. The site of the accident is first visited, and a careful investigation made of all the circumstances attending the disaster. An adjournment is then made to a room, and the evidence of the various witnesses is taken down verbatim. The court is not a court of law, and witnesses are not examined in oath, nor is the officer bound by the strict law of evidence; it is simply a court of inquiry. The admission of the general public and of the press rests within the discretion of the officer; the usual practice being to admit the press and public in cases of general interest, unless there has been loss of life, and there is any chance of any servant of the company, or of any other person, being put upon his trial for manslaughter or other grave offence, such as criminal negligence, in which case it is not as a rule considered advisable to admit the press, etc., lest the person implicated might be prejudiced by anything that transpired during the inquiry. It must be clearly borne in mind that the inquiry by the Board of Trade is for the purpose of ascertaining the cause of the accident with the view of preventing a recurrence of the same, and not for the purpose of penalizing anyone; the latter is left to be dealt with by the usual process of law. A Board of Trade inquiry, therefore, is in addition to, and independent of, any proceedings before the coroner or magistrate. The Act of 1871 confers upon the coroner, when holding an inquest on the death of a person occasioned by a railroad accident, the right to request the Board of Trade to appoint an inspector, or some person possessing special knowledge, to act as assessor to the coroner, and this is sometimes done. But such a course does not prevent the department from holding an independent inquiry. The same Act empowers the Board of Trade to hold what is called a "formal investigation" into the cause of any accident in lieu of, or in addition to, the less formal inquiry to which reference has been made. In the event of such "formal investigation" being held, the Board may appoint "any person or persons possessing special or legal knowledge to assist an inspector holding the inquiry," or may "direct the county court judge, stipendiary magistrate, metropolitan police magistrate, or other person" to hold the inquiry with the assistance of an inspector or any other assessor. Such an investigation has to be held in open court, and the witnesses may be examined on oath, and the court has all the powers of a court of summary jurisdiction, besides all the powers of an inspector under the Act. But the necessity for holding such a formal investigation has very rarely arisen. The inspector after making his inquiry is required to make to the Board of Trade a report as to the causes of the accident and the circumstances attending the same, with any observations on the subject which he deems right, and the Board "shall cause every such report to be made public in such manner as they think expedient." The usual manner of publishing such reports is to forward them to the railroad companies concerned, and to the press, and to anyone else who is interested. The reports are subsequently included in a "blue book" and presented to Parliament. It should be noted that although the officer may in his report make recommendations with a view to guarding against any similar accident occurring in the future, no power is given to the Board of Trade, or any other authority, to compel any railroad company to adopt such recommendations. This omission is sometimes criticized as a defect in the Act, but it is not really so. The moral effect of the publication of the report with the criticisms of the company's methods is great, and it seldom happens that a company refuses to adopt, or at least to test the recommendations made by the officer wo held the inquiry. If, however, the company is of opinion that the suggestions of the officer are not likely to be useful, or are for any reason inexpedient, the company is at liberty to reject them, the responsibility of so doing resting on it. The effect of this latitude is to give the company discretion in the matter, and to enable the Act of Parliament to be administered without undue interference.

An important Act was passed in 1889, putting on the Board of Trade the duty of calling upon all railroad companies throughout the United Kingdom to adopt upon all lines carrying passengers the system of block working; to interlock points and signals, and to fit all trains carrying passengers with "continuous brakes." A reasonable time was allowed to the companies in which to comply, and the work is now practically complete. In respect of block working and interlocking, therefore, the lines of the United Kingdom are far ahead of those of any other country, and a marked diminution of accidents, particularly of collisions, has resulted from this cause. The use of the electric staff or electric tablet for single line working, which practically combines the principle of block working with the use of the ordinary train staff, is held to be a compliance with the Act. If, however, the ordinary train staff is used in conjunction with train "tickets," then block instruments have to be provided in addition. When the line is of such small importance that the traffic can be handled by one engine in steam, block instruments are, of course not required. The effect of the regulations is that single lines as well as double lines in Great Britain are worked with a remarkable immunity from accident, and head-on collisions are almost unknown.

In addition to the Acts of Parliament safeguarding the interests of passengers, recent legislation has been directed to the protection of the servants of railroad companies, and investigations are held into numerous cases of injury, fatal or otherwise, which befall railroad men. A code of rules has been drawn up by direction of Parliament for the safety of the men, and further rules are at present under consideration.

There are four inspecting officers, whose duties are chiefly, though not entirely, confined to inspection of new railroads and tramways, or new works on railroads, *e. g.*, signal boxes, stations, sidings, junctions, etc., and to the investigation of accidents to trains. There are also two assistant inspecting officers and three sub-inspectors, whose duties are chiefly directed to the investigation of accidents to railway servants. The above staff deals with all the railroads and tramways in the United Kingdom, including Scotland and Ireland. The duties are sufficiently onerous and responsible. The relations between the officers of the Board of Trade and the officers of the railroad companies are of a friendly nature, and the latter do all they can to assist the former in the performance of their duties.

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[**016** .385. (02]

I. — BIBLIOGRAPHY OF BOOKS

(June, 1907.)

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Bruxelles, M. Weissenbruch, imprimeur du Roi. In-4° (275 × 185), 214 pages, cartes et planches. (Prix : 4 francs).

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SARTIAUX (Albert).

Le tunnel sous-marin entre la France et l'Angleterre. Conférence faite à la Société industrielle du Nord de la France, le 20 janvier 1907.

Lille, imprimerie Danel. In-8°, 59 pages et figures.

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SOUCHON (Auguste), professeur à l'école de droit de Paris, & **MANGE** (Alfred), ingénieur, chef adjoint de l'exploitation à la Compagnie d'Orléans.

Le rachat des chemins de fer Conférence faite, le 8 décembre 1906, à la Fédération des industriels et commerçants français.

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Die Eisenbahn-Technik der Gegenwart. IV. B 1. Abschn. B und C. : Abt. **Stadtbahnen. Lokomotiven und Triebwagen für Schmalspur-, Förder-, Strassen- und Zahn-Bahnen.**

Wiesbaden, C. W. Kreidel. In-8°, xii-177-509 Seiten, 325 Abbildungen im Texte und 16 lithographirten Tafeln. (Preis : 12.60 Mark.)

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Denkschrift betr. die Eisenbahnen Afrikas. Grundlagen und Gesichtspunkte für eine koloniale Eisenbahnpolitik in Afrika.

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[1] The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels. (See "Bibliographical Decimal Classification as applied to Railway Science," by L. Weissenbruch, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

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Brücken in Eisenbeton. Ein Leitfaden für Schule und Praxis. I. Teil : Platten- und Balkenbrücken.
Berlin, W. Ernst & Sohn. In-8°, v-142 Seiten mit 360 Abbildungen. (Preis : 4 Mark.)

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1907 **62**. (02
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Cassell's engineers' hand-book.
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DAWSON (Philip).
The engineering and electric traction pocket-book.
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Graphical handbook for reinforced concrete design.
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The American steel worker : a 25 years' experience in the selection, annealing, working, hardening and tempering of various kinds and grades of steel.
New York, Derry-Collard Co. Second edition, 8^{vo}, 7 + 339 + 28 pages, il., pl., diagrams. (Price : $2.50.)

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MORITZ (Ernest Anthony).
Tests on reinforced concrete beams.
Madison, Wis. University of Wisconsin. 8^{vo}, 319-304 pages, pl., diagrams, tables. (Price : 30 cents.)

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The commercial organisation of engineering factories.
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Modern British locomotives.

London, Spon. 8vo, 100 diagrams and principal dimensions. (Price : 4*s*. 6*d*.)

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Locomotive breakdown questions. — Answered and illustrated.

Chicago, Ill., Frederick J. Drake & Co. (7 × 4 1/2 inches), 285 pages, text illustrations and folding plates. (Price : $1.50.)

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[016 .385. (05]

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(Bruxelles.)

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ALLEN (W. F.). — L'emploi réciproque du matériel à marchandises sur les chemins de fer de l'Amérique du Nord. (5,800 mots.)

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ROUS-MARTEN (Charles). — Les locomotives britanniques en 1906. (7,900 mots & fig.)

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Une automotrice allemande. (900 mots & fig.)

1907 **656** .283
Bulletin du Congrès des chemins de fer, nº 5, mai, p. 537.

Les causes des collisions sur les chemins de fer des États-Unis. (1,300 mots & fig.)

1907 **385**. (06.111
Bulletin du Congrès des chemins de fer, nº 5, mai, p. 540.

Documents officiels de la Commission permanente de l'Association internationale du Congrès des chemins de fer : Liste des questions soumises aux discussions de la huitième session du Congrès des chemins de fer (Berne, 1910), avec indication des noms des rapporteurs. (2,800 mots.)

1907 **385**. (09.2
Bulletin du Congrès des chemins de fer, nº 5, mai, p. 550.

Nécrologie : Jean ADADOUROV. (1,500 mots & portrait.)

1907 **621**. 13 & **385**. (04
Bulletin du Congrès des chemins de fer, nº 5, mai, p. 555.

Comptes rendus bibliographiques : Les locomotives à l'Exposition de Liége (1905), par A. HERDNER. (200 mots.)

1907 **016** .385. (02
Bulletin du Congrès des chemins de fer, nº 5, mai, p. 59.

Bibliographie mensuelle des chemins de fer. — Livres. (40 fiches.)

1907 **016** .385. (05
Bulletin du Congrès des chemins de fer, nº 5, mai, p. 63.

Bibliographie mensuelle des chemins de fer. — Périodiques. (213 fiches.)

Bulletin de la Société d'encouragement pour l'industrie nationale. (Paris.)

1907 **621** .14
Bulletin de la Société d'encourag. pour l'ind. nat., avril, p. 465.

Les autobus à pétrole. (1,800 mots & fig.)

Bulletin des transports internationaux par chemins de fer. (Berne.)

1907 **385** .589 (.439)
Bulletin des transports intern. par chemins de fer, mai, p. 176.

La grève des employés de chemins de fer hongrois et la force majeure. (2,400 mots.)

Génie civil. (Paris.)

1907 **625** .144.4
Génie civil, nº 1299, 4 mai, p. 8.

MESNAGER. — Mesure des déplacements relatifs des rails. Appareil Reitler. (1,200 mots & fig.)

1907 **625** .143.4
Génie civil, nº 1300, 11 mai, p. 28.

LAFONTANT (J.). — Nouveau système d'éclissage sans boulons. (700 mots & fig.)

Journal des transports. (Paris.)

1907 **385** .113 (.44)
Journal des transports, nº 18, 4 mai, p. 205.

Les résultats de 1906. — Réseau de l'Ouest. (2,800 mots & 3 tableaux.)

1907 **385** .1 (.42 + .43)
Journal des transports, nº 19, 11 mai, p. 217.

Les chemins de fer et leurs rapports avec le commerce en Angleterre et en Allemagne. (3,000 mots.)

1907 **385** .113 (.44)
Journal des transports, nº 20, 18 mai, p. 229.

Les résultats de 1906. — Réseau P. L. M. (2,400 mots & 3 tableaux.)

1907 **385** .113 (.44)
Journal des transports, nº 21, 25 mai, p. 241.

Les résultats de 1906. — Réseau du Midi. (2,200 mots & 1 tableau.)

1907 **385** .113 (.44)
Journal des transports, nº 22, 1er juin, p. 253.

Les résultats de 1906. — Réseau d'Orléans. (3,000 mots.)

Nouvelles annales de la construction. (Paris.)

1907 **656** .211.7
Nouvelles annales de la construction, nº 629, mai, p. 65.

Pont à transbordeur de Runcorn (Angleterre). (4,700 mots & fig.)

1907 **721** .9
Nouvelles annales de la construction, nº 629, mai, p. 72.

Emploi du béton armé. — Circulaire ministérielle du 20 octobre 1906. (4,500 mots, 4 tableaux & fig.)

Revue générale des chemins de fer et des tramways. (Paris.)

1907 **656** .211.5
Revue générale des chemins de fer, nº 5, mai, p. 239.

COSSMANN & DESPONS (E.). — La reconstruction de la gare de Valenciennes. (2,500 mots & fig.)

1907 **621** .135. (01
Revue générale des chemins de fer, nº 5, mai, p. 249.

MARIÉ (G.). — Les oscillations du matériel dues au matériel lui-même et les grandes vitesses des chemins de fer. (16,500 mots & fig.)

1907 **313** .385 (.493)
Revue générale des chemins de fer, nº 5, mai, p. 291.

Statistique des chemins de fer de la Belgique pour l'année 1905. (500 mots & tableaux.)

1907 **385** .3 (08 (.73)
Revue générale des chemins de fer, nº 5, mai, p. 298.

Rapport de l'Interstate Commerce Commission des États-Unis pour l'exercice 1905-1906. (3,500 mots.)

1907 **656** .253
Revue générale des chemins de fer, nº 5, mai, p. 301.

Exposition de Milan 1906. — Appareils exposés par les chemins de fer de l'État italien. — Appareil avertisseur à pétards Coen-Cagli. (1,800 mots & fig.)

1907 **656** .257
Revue générale des chemins de fer, nº 5, mai, p. 304.

Appareils complémentaires des commandes électro-magnétiques des aiguilles et des signaux expérimentées à la station de Courcelles-ceinture sur le chemin de fer de petite ceinture de Paris. (700 mots & fig.)

1907 **621** .131.3
Revue générale des chemins de fer, nº 5, mai, p. 306.

Essais de locomotives à vapeur surchauffée. (1,200 mots & 3 tableaux.)

Revue de mécanique. (Paris.)

1907 **62**. (01
Revue de mécanique, avril, p. 313.

BREUIL (P.). — Nouveaux mécanismes et nouvelles méthodes pour l'essai des métaux. (12,800 mots & fig.)

Revue politique et parlementaire. (Paris.)

1907 **385** .113 (.4)
Revue politique et parlementaire, nº 155, mai, p. 399.

COLSON (C.). — Revue des questions de transports. — Les chemins de fer en 1905-1906. (6,200 mots & 2 tableaux.)

In German.

Annalen für Gewerbe und Bauwesen. (Berlin.)

1907 **625** .13
Annalen für Gewerbe und Bauwesen, Nr 718, 15. Mai, S. 193.

PRESSEL. — Der Bau des Simplontunnels. (3 700 Wörter & Abb.)

1907 **621** .33

Annalen für Gewerbe und Bauwesen, Nr 718, 15. Mai, S. 201.

PFORR (Ph.). — Der elektrische Vollbahnbetrieb. (7 000 Wörter & Abb.)

Archiv für Eisenbahnwesen. (Berlin.)

1907 **313** .385 (.3)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 635.

Die Eisenbahnen der Erde. (900 Wörter & Tabellen.)

1907 **313** : **656** .28 (.3)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 646.

GUILLERY (C.). — Die Betriebssicherheit der Eisenbahnen. (1 700 Wörter & 1 Tabelle.)

1907 **385** .1

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 660.

FRANKE (G.). — Unwirtschaftliche Gütertransporte in den Vereinigten Staaten von Amerika. (1 200 Wörter.)

1907 **656** .24 & **656** .28 (01

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 664.

LENTZE. — Zur Regelung der Haftpflichtansprüche bei traumatischer Neurose und verwandten Krankheiten. (8 000 Wörter.)

1907 **385** .1 (.431)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 686.

SCHREMMER. — Der Etat der preussisch-hessischen Eisenbahnverwaltungen für das Etatsjahr 1907. (800 Wörter & Tabellen.)

1907 **313** .385 (.43)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 700.

THAMER (C.). — Deutschlands Getreideernte im Jahre 1905 und die Eisenbahnen. (200 Wörter & Tabellen.)

1907 **313** .385.517 (.433)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 726.

Wohlfahrtseinrichtungen der königliche bayerischen Staatseisenbahnen im Jahre 1905. (2 000 Wörter & Tabellen.)

1907 **313** .385 (.434)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 735.

Der königlich württembergischen Staatseisenbahnen und die Bodenseedampfschiffahrt im Etatsjahr 1905. (Tabellen.)

1907 **313** .385 (.481)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 745.

Die Eisenbahnen in Norwegen im Jahre 1905-1906. (Tabellen.)

1907 **313** .385 (.485)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 752.

Die schwedischen Staatsbahnen im Jahre 1905. (Tabellen.)

1907 **313** .385 (.489)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 756.

Die Eisenbahnen in Dänemark im Betriebsjahr 1905-1906. (700 Wörter & Tabellen.)

1907 **385**. (09.1 (.47)

Archiv für Eisenbahnwesen, Heft 3, Mai-Juni, S. 775.

Die russischen Verkehrswege und ihre Anforderungen in der nächsten Zukunft. (3 200 Wörter.)

Bulletin des internationalen Eisenbahn-Kongress-Verbandes. (Brüssel.)

1907 **625** .14 (01

Bulletin des Eisenbahn-Kongresses. Nr 5, Mai, S. 423.

SCHLÜSSEL (L.). — Ueber die wirtschaftliche Erneuerung und Unterhaltung der für grosse Geschwindigkeiten geeigneten Gleise. (11 400 Wörter, 1 Tabelle & Abb.)

1907 **656** .222.1 (.431 + .73)

Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 461.

SCHULZE (W. A.). — Die Fahrgeschwindigkeit der amerikanischen und deutschen Eisenbahnen. (4 300 Wörter.)

1907 **656** .237.2

Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 470.

HERVIEU (J.). — Apparat zum Drucken, Ausgeben und Zählen der Eisenbahnfahrkarten. (5 100 Wörter & Abb.)

1907 **621** .133.2

Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 485.

Bewegliche Stehbolzen. (3 400 Wörter & Abb.)

1907 **621** .133.5

Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 493.

Versuche des « American Engineer » über Anordnungen zur Herbeiführung des Zuges in Lokomotiven. (2 800 Wörter & Abb.)

1907 **385**. (07.11 & **727** .4
Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 500.

Das neue Ingenieur-Gebäude der Universität von Pennsylvanien. (4 200 Wörter & Abb.)

1907 **656** .256
Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 509.

Blocksignale auf amerikanischen Eisenbahnen. (350 Wörter & 1 Tabelle.)

1907 **625** .216
Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 514.

Der « Darling » Selbstkuppler (System Davidson). (350 Wörter & Abb.)

1907 **621** .134.5
Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 514.

Einfache Dampfdehnung und niedrigere Dampfdrücke. (1 050 Wörter.)

1907 **725** .31
Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 517.

Geplanter Untergrundbahnhof der Hudson-River Tunnelbahn. (900 Wörter & Abb.)

1907 **385** .15 (.45)
Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 521.

Nachrichten von den italienischen Staatsbahnen. (2 150 Wörter.)

1907 **385**. (06.111
Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 526.

Fragen für die achte Sitzung des Eisenbahn-Kongresses (Bern, 1910) und Verzeichnis der Berichterstatter. (Amtliche Dokumente der Ständigen Kommission des Internationalen Eisenbahn-Kongress-Verbandes. (2 500 Wörter.)

1907 **016** .385. (02
Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 59.

Monatliches Verzeichnis der Eisenbahnliteratur. — Bücher. (40 Zettel.)

1907 **016** .385. (05
Bulletin des Eisenbahn-Kongresses, Nr 5, Mai, S. 63.

Monatliches Verzeichnis der Eisenbahnliteratur. — Zeitschriften. (213 Zettel.)

Œsterreichische Eisenbahn-Zeitung. (Wien.)

1907 **385** .517
Œsterreichische Eisenbahn-Zeitung, Nr 15, 1. Mai, S. 133.

STEIN (M.). — Der Einfluss der Verstaatlichung auf die Krankenversicherung der Bahnbeamten und die Krankenkassenorganisation. (1 800 Wörter.)

1907 **625** .233
Œsterreichische Eisenbahn-Zeitung, Nr 16, 15. Mai, S. 145.

SPITZER (K.). — Ueber Azetylen-Beleuchtung bei Eisenbahnen. (4 200 Wörter.)

Elektrische Bahnen und Betriebe. Zeitschrift für Verkehrs- und Transportwesen.
(München.)

1907 **621** .33 & **625** .3
Elektrische Bahnen u. Betriebe, Heft 13, 4. Mai, S. 250.

HERZOG (S.). — Die Arth-Rigibahn. (1 200 Wörter & Abb.)

1907 **621** .33
Elektrische Bahnen u. Betriebe, Heft 15, 24. Mai, S. 289.

REICHEL (W.). — Ueber die Einführung des elektrischen Zugbetriebes auf den Berliner Stadt-, Ring- und Vorortbahnen. (1 500 Wörter.)

Schweizerische Bauzeitung. (Zürich.)

1907 **624** .62
Schweizerische Bauzeitung, Nr 19, 11. Mai, S. 229.

ACKERMANN (F.). — Die Eisenbahnbrücke über das Schwarzwassertobel. (1 100 Wörter & Abb.)

1907 **621** .33
Schweizerische Bauzeitung, Nr 20, 18. Mai, S. 247.
— — Nr 21, 25. — S. 256.

KUMMER (W.). — Vorausberechnung und Beurteilung der charakteristischen Kurven von Seriemotoren für Gleichstrom und Wechselstrom hinsichtlich der Bedürfnisse der elektrischen Traktion. (4 000 Wörter & Abb.)

Zeitschrift für Kleinbahnen. (Berlin.)

1907 **621** .131.1 & **625** .251
Zeitschrift für Kleinbahnen, Heft 5, Mai, S. 313.

HILDEBRAND (W.). — Warum ist die Frage nach einem sicher wirkenden Sandstreuer so dringend geworden? (1 900 Wörter.)

1907 **621** .13 & **621** .33
Zeitschrift für Kleinbahnen, Heft 5, Mai, S. 316.

ŽEŽULA (F.). — Dampfbetrieb oder elektrischer Betrieb? (3 800 Wörter & Tabellen.)

Zeitschrift des Vereines deutscher Ingenieure. (Berlin.)

1907 **621** .13 (06.4
Zeitsch. des Vereines deutscher Ingen., Nr 18, 4. Mai, S. 686.

METZELTIN. — Die Eisenbahnbetriebsmittel auf der Ausstellung in Mailand 1906. (3 600 Wörter, 2 Tabellen & Abb.)

1907 **624** .32
Zeitsch. des Vereines deutscher Ingen., Nr 19, 11. Mai, S. 725.

DIETZ (W.). — Die Strassenbrücke über den Rhein zwischen Ruhrort und Homberg. (3 700 Wörter & Abb.)

1907 **656** .212 (.73)
Zeitsch. des Vereines deutscher Ingen., Nr 19, 11. Mai, S. 738.
— — Nr 21, 25. — S. 813.

BLUM & GIESE (E.). — Einige Bemerkungen über die Güterbahnhöfe in Nordamerika. (4 000 Wörter & Abb.)

1907 **621** .116. (01 & **621** .133. (01
Zeitsch. des Vereines deutscher Ingen., Nr 19, 11. Mai, S. 747.

BACH (C.). — Ergebnisse der Untersuchung eines bei der Druckprobe aufgerissenen Kesselbleches. (1 300 Wörter & Abb.)

1907 **625** .13
Zeitsch. des Vereines deutscher Ingen., Nr 21, 25. Mai, S. 805.

BRABBÉE (K.). — Die maschinellen Anlagen beim Bau des Tauerntunnels. (5 000 Wörter & Abb.)

1907 **385**. (01 (.6)
Zeitsch. des Vereines deutscher Ingen., Nr 21, 25. Mai, S. 824.

MATSCHOSS (C.). — Die Eisenbahnen Afrikas. (4 000 Wörter, 2 Tabellen & Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1907 **625** .72
Zeitung des Vereins, Nr 33, 1. Mai, S. 523.

HEUBACH. — Die Unterhaltung der Eisenbahngleise in den Kurven. (1 700 Wörter & Abb.)

1907 **656** .234
Zeitung des Vereins, Nr 33, 1. Mai, S. 526.

SCHULZE (W. A.). — Zur Gepäcktarifreform. (1 200 Wörter & 2 Tabellen.)

1907 **656** .234
Zeitung des Vereins, Nr 34, 4. Mai, S. 539.

DRILLING. — Vereinfachtes Verfahren zur Abfertigung von Gepäck bis 25 Kilogram. (1 000 Wörter & Abb.)

1907 **621** .134.3
Zeitung des Vereins, Nr 35, 8. Mai, S. 557.

WOLFF. — Die Heissdampflokomotiven. (2 300 Wörter & 1 Tabelle.)

1907 **656** .222.3
Zeitung des Vereins, Nr 36, 11. Mai, S. 573.

SCHILZ. — Der Zugbildungsplan. (1 600 Wörter & 3 Tabellen.)

1907 **656** .253
Zeitung des Vereins, Nr 39, 25. Mai, S. 625.

DUFOUR (L. H. N.). — Benutzung von Signalen an Signalmasten auf Bahnhöfen für fahrplanmässige und rangierende Züge. (1 400 Wörter & Abb.)

In English.

American Engineer and Railroad Journal. (New York)

1907 **625** .246 & **625** .26
American Engineer & R. Journal, May, p. 157.

Maintenance and repair of steel freight cars. (8,000 words, 2 tables & fig.)

Bulletin of the American Railway Engineering and Maintenance of Way Association. (Chicago.)

1907 **385** .11
Bull. Amer. Ry. Eng. & Maint. of Way Ass., No. 84, Feb., p. 4.

Economics of railway location. (29,000 words, tables & fig.)

Bulletin of the International Railway Congress Association. (Brussels.)

1907 **621** .132.1 (.42)
Bulletin of the Railway Congress, No. 5, May, p. 479.

ROUS-MARTEN (Charles). — British locomotives in 1906. Designs and work. (6,300 words & fig.)

1907 **621** .14
Bulletin of the Railway Congress, No. 5, May, p. 495.

VELLGUTH.— The present cost of motor bus services (12,700 words & 4 tables.)

1907 **656** .259
Bulletin of the Railway Congress, No. 5, May, p. 521.

MAAS-GEESTERANUS (H. P.). — New apparatus for controlling the speed of trains. (1,900 words & fig.)

1907 **669**
Bulletin of the Railway Congress, No. 5, May, p. 526.

SUGGATE (Alfred). — Bearing alloys. (5,200 words, 2 tables & fig.)

1907 **656** .237.2
Bulletin of the Railway Congress, No. 5, May, p. 539.

HERVIEU (J.). — Machine for printing, issuing and checking railway tickets. (5,000 words & fig.)

1907 **656** .222.1 (.431 + .73)
Bulletin of the Railway Congress, No. 5, May, p. 552.

SCHULZE (W. A.). — Train speeds on American and German railways. (4,800 words.)

1907 **656** .254
Bulletin of the Railway Congress, No. 5, May, p. 560.

Wireless telegraphy in railway work. (400 words.)

1907 **621** .132.8
Bulletin of the Railway Congress, No. 5, May, p. 561.

A German motor car. (800 words & fig.)

1907 **385** .15 (.45)
Bulletin of the Railway Congress, No. 5, May, p. 563.

Notes on the Italian State Railways. (2,400 words.)

1907 **656** .283
Bulletin of the Railway Congress, No. 5, May, p. 566.

The causes of railway collisions. (2,000 words & 2 tables.)

1907 **385**. (06.111
Bulletin of the Railway Congress, No. 5, May, p. 572.

List of the questions for discussion at the eighth session of the Railway Congress (Bern, 1910) with indication of the names of the reporters. (Official information issued by the Permanent Commission of the International Railway Congress Association.) (3,000 words.)

1907 **385**. (09.2
Bulletin of the Railway Congress, No. 5, May, p. 582.

Obituary : Jean Adadourov. (1,550 words & portrait.)

A.

1907 **016** .385. (02
Bulletin of the Railway Congress, No. 5, May, p. 59.

Monthly bibliography of railways. — Books. (40 labels.)

1907 **016** .385. (05
Bulletin of the Railway Congress, No. 5, May, p. 63.

Monthly bibliography of railways. — Periodicals. (213 labels.)

Engineer. (London.

1907 **621** .33
Engineer, No. 2680, May 10, p. 480.

A new mono-railway. (900 words & fig.)

1907 **625** .13
Engineer, No. 2680, May 10, p. 481.

Ventilating a German tunnel. (900 words & fig.)

1907 **621** .132.5
Engineer, No. 2681, May 17, p. 491.

Compound locomotive, St. Gothard Railway. (700 words & fig.)

1907 **385** .51 (.42)
Engineer, No. 2681, May 17, p. 509.

Railways and railwaymen. (2,400 words).

Engineering. (London.)

1907 **669** .1
Engineering, No. 2157, May 3, p. 569.
— No. 2159, — 17, p. 633.

CARPENTER (H. C. H.). — An analysis of the evolution of modern tool-steel. (8,000 words & fig.)

1907 **51**. (08
Engineering, No. 2157, May 3, p. 580.

The Burroughs adding and listing-machine. (3,000 words & fig.)

1907 **624** .32
Engineering, No. 2158, May 10, p. 603.
— No. 2160, — 24, p. 673.

Smallheath bridge, Birmingham. (6,200 words & fig.

1907 **621** .132.8
Engineering, No. 2159, May 17, p. 643.

Rack locomotive for the Transandine Railway. (1,300 words & fig.)

Engineering Magazine. (London.)

1907 **385.** (07.1 (.73)
Engineering Magazine, May, p. 171.

WARREN (F. B.). — A railroad university. Altoona and its methods. (1,800 words & fig.)

1907 **621** .33 & **625** .4
Engineering Magazine, May, p. 195.

VAN BRUSSEL (J. B.). — Electric traction in the Simplon railway tunnel. (2,200 words & fig.)

1907 **621** .112 & **621** .134.3
Engineering Magazine, May, p. 209.

BOLTON (R. P.). — Present practice in the use of superheated steam. (3,500 words & fig.)

1907 **621** .7
Engineering Magazine, May, p. 239.

KNOEPPEL (C. E.). — Cost reduction through cost comparison. (3,000 words & fig.)

Engineering News. (New York.)

1907 **621** .132.8
Engineering News, No. 17, April 25, p. 445.

A steam motor car for railway service. (550 words & fig.)

1907 **624** .63
Engineering News, No. 19, May 9, p. 497.

The Sandy Hill bridge over the Hudson River; a long reinforced-concrete arch bridge with block facing. (6,000 words & fig.)

1907 **656** .256. (01
Engineering News, No. 19, May 9, p. 514.

Some recent developments in railway block signaling. (3,800 words.)

1907 **656** .222.1
Engineering News, No. 20, May 16, p. 530.

Train resistance and the economics of railway location. (5,000 words.)

Journal of the Franklin Institute. (Philadelphia.)

1907 **656** .256.3 (.73)
Journal of the Franklin Institute, April, p. 311.

IRWIN (J. C.). — Railroad management and Safety devices. (5,500 words.)

1907 **621** .132.1
Journal of the Franklin Institute, May, p. 331.

WARNER (P. T.). — The modern locomotive. (6,500 words & fig.)

Journal of the West of Scotland Iron and Stee Institute. (Glasgow.)

1907 **621** .112
Journ.of the West of Sc.I.& St.Inst.,Nos.5-6,Feb.-March,p.186.

MELLANBY (A. L.). — Superheated steam. (5,500 words, 1 table & fig.)

Locomotive Firemen and Enginemen's Magazine. (Indianapolis.)

1907 **388** (.73)
Locomotive Firemen and Enginemen's Magazine, May, p. 603.

The solution of New York's transportation problem. (1,200 words & fig.)

1907 **621** .131.1
Locomotive Firemen and Enginemen's Magazine, May, p. 612.

The actual efficiency of a modern locomotive. (4,200 words, tables & fig.)

1907 **656** .256.3 (.73)
Locomotive Firemen and Enginemen's Magazine, May, p. 637.

Block signal systems and automatic control of railway trains. (4,500 words.)

Page's Weekly. (London.)

1907 **621** .132.7 & **621** .335
Page's Weekly, No. 141, May 24, p. 1093.

UYTBORCK (E.). — Petrol-electric (mixed traction) locomotive employed on the Belgian State Railways for shunting goods wagons. (2,000 words & fig.) (S. *Bulletin of the Railway Congress*, No. 4, April 1907.)

Permanent Way Institution. (London.)

1907 625 .142.4 (.73)
Permanent Way Institution, April, p. 97.

CAMP (W. M.). — Experiments with reinforced concrete ties in America. (3,600 words & fig.)

Proceedings of the American Society of Civil Engineers. (New York.)

1907 **624** .63

Proceedings of the American Soc. of Civil Eng., April, p. 394.

BURR (W. H.). — The reinforced concrete bridge across the Hudson River at Sandy Hill, New York. (3,200 words & fig.)

1907 **624** .8

Proceedings of the American Soc. of Civil Eng., May, p. 528.

Movable bridges. (1,900 words & fig.)

Railroad Gazette. (New York.)

1907 **621** .132.3

Railroad Gazette, No. 17, April 26, p. 572.

Ten-wheel locomotive for the St. Louis & San Francisco. (400 words & fig.)

1907 **625** .143.5

Railroad Gazette, No. 17, April 26, p. 580.

Holding force of railroad spikes in wooden ties. (400 words, 6 tables & fig.)

1907 **656** .223.2

Railroad Gazette, No. 17, April 26, p. 581.

The freight car situation. (2,400 words.)

1907 **621** .14 & **621** .132.8

Railroad Gazette, No. 18, May 3, p. 606.

Pennsylvania report on motor cars. (3,000 words)

1907 **656** .257

Railroad Gazette, No. 18, May 3, p. 610.

ARKENBURGH (W. H.). — Electric locking. (3,200 words & fig.)

1907 **625** .232

Railroad Gazette, No. 18, May 3, p. 623.

Combination parlor, sleeping and dining cars for the Canadian Northern. (500 words & fig.)

1907 388. (09.1 (.73)

Railroad Gazette, No. 19, May 10, p. 644.
— No. 20, — 17, p. 670.

The rehabilitation of the Brooklyn Rapid Transit Company. (7,300 words & fig.)

1907 **625** .143.2 (.73)

Railroad Gazette, No. 20, May 17, p. 674.

Defective rails. (3,700 words & fig.)

Railway Age. (Chicago.)

1907 **625** .232

Railway Age, No. 1610, April 19, p. 636.

The first steel Pullman sleeping car. (800 words & fig.)

1907 **621** .132.3

Railway Age, No. 1610, April 19, p. 638.

Ten-wheel locomotive for the « Frisco ». (300 words & fig.)

1907 385. (07.2 & **621** .131·3

Railway Age, No. 1613, May 10, p. 734.

Locomotive testing plant of the Pennsylvania Railroad at Altoona. (800 words & fig.)

1907 **621** .132.5

Railway Age, No. 1613, May 10, p. 746.

Decapod locomotive for the Buffalo Rochester & Pittsburg. (950 words & fig.)

1907 **621** .132.5

Railway Age, No. 1614, May 17, p. 778.

Consolidation locomotive for the Western Pacific Railway. (250 words & fig.)

Railway Engineer. (London.)

1907 **625** .4

Railway Engineer, No. 328, May, p. 137.

Underground stations at Finsbury Park; Great Northern Railway. (3,800 words & fig.)

1907 **656** .257

Railway Engineer, No. 328, May, p. 149.

Low pressure pneumatic signalling at Ermont; Northern Railway of France. (1,400 words & fig.)

1907 **656** .222.1 (.44)

Railway Engineer, No. 328, May, p. 156.

KING (Chas. R.). — 200-mile run with a De Glehn « Atlantic » engine. (1,300 words & fig.)

Railway and Engineering Review. (Chicago.)

1907 **656** .256
Railway and Engineering Review, No. 16, April 20, p. 334.
— — — — No. 20, Mai 18, p. 423.

Joint discussion of block signal systems. (12,800 words & fig.)

1907 **625** .143.2
Railway and Engineering Review, No. 16, April 20, p. 344.

TALBOT (B.).— Open hearth steel rails. (3,300 words.)

1907 **656** .223.2 (.73)
Railway and Engineering Review, No. 17, April 27, p. 359.

Car efficiency. (4,200 words.)

1907 **621** .132.8
Railway and Engineering Review, No. 17, April 27, p. 361.

Gasoline motor cars for railway service. (3,400 words, 2 tables & fig.)

1907 **656** .223.2 (.73)
Railway and Engineering Review, No. 17, April 27, p. 365.

Car clearing houses, car pools, etc. (4,000 words.)

1907 **385**. (07.2 & **621** .131.3
Railway and Engineering Review, No. 18, May 4, p. 375.

Locomotive testing plant of the Pennsylvania Railroad at Altoona. (2,200 words & fig.)

Railway Gazette. (London.)

1907 **621** .32 & **625** .233
Railway Gazette, Nô. 18, May 3, p. 417.

The Verity-Dalziel system of electric train lighting. (2,000 words & fig.)

1907 **621** .33
Railway Gazette, No. 19, May 10, p. 439.

HOBART (H. M.). — Rival electric railway systems. (5,000 words & fig.)

1907 **656** .234 & **656** .235
Railway Gazette, No. 20, May 17, p. 465.

MARRIOTT (H.) — The fixing of rates and fares. (1,300 words & 2 tables.)

1907 **656** .235 (.42)
Railway Gazette, No. 21, May 24, p. 487.

The economical working of goods traffic. (2,200 words & fig.)

Railway and Locomotive Engineering. (New York.)

1907 **624** .51
Railway and Locomotive Engineering, May, p. 191.

Suspension bridges. (1,600 words & fig.)

1907 **621** .137.1
Railway and Locomotive Engineering, May, p. 219.

Mechanical stoker on the Erie. (2,200 words & fig.)

Railway Machinery. (New York.)

1907 **621** .132.8
Railway Machinery, May, p. 473.

Gasoline motor cars for railway service. (2,700 words & fig.)

Railway Magazine. (London.)

1907 **656** .222.1 (.42)
Railway Magazine, No. 119, May, p. 402.

ROUS-MARTEN (C.). — British locomotive practice and performance. (3,500 words & fig.)

Railway Master Mechanic. (Chicago.)

1907 **621** .134.4
Railway Master Mechanic, May, p. 150.

CAMPBELL (H. A. F.). — The four cylinder balanced compound in actual service. (3,200 words, 4 tables & fig.)

Railway News. (London.)

1907 **656** .253
Railway News, No. 2261, May 4, p. 878.

EDWARDS (W. E.).— The evolution of the semaphore. (900 words & fig.)

1907 **621** .32 & **625** .233
Railway News, No. 2261, May 4, p. 877.

The Verity-Dalziel system of train lighting. (1,400 words & fig.)

1907 **621** .33 & **625** .4
Railway News, No. 2262, May 11, p. 919.

The City and South London Railway : Opening of the extention to King's cross, St. Pancras, and Euston. (2,000 words & fig.)

Railway Times. (London.)

1907 **621** .33 & **625** .4
Railway Times, No. 19, May 11, p. 483.

City and South London Railway. (900 words & fig.)

South African Railway Magazine. (Johannesburg.)

1907 **621** .133.1
South African Railway Magazine, April, p. 33.

HOBART (J. F.). — Burning low-grade fuel. (2,900 words.)

1907 **621** .332
South African Railway Magazine, April, p. 41.

NORMAN (G. F. A.). — The transmission and distribution of electrical energy. (4,000 words & fig.)

Street Railway Journal. (New York.)

1907 **621** .132.8
Street Railway Journal, No. 17, April 27, p. 732.

Gasoline motor cars for railway service. (3,000 words, 2 tables & fig.)

1907 **728** .1 (.43)
Street Railway Journal, No. 18, May 4, p. 771.

The construction of employees' homes by German electric railways. (3,000 words & fig.)

1907 **621** .33
Street Railway Journal, No. 21, May 25, p. 907.

SPRAGUE (F. J.). — Some facts and problems bearing on electric trunk-line operation. (10,000 words & fig.)

Tramway & Railway World. (London.)

1907 **621** .33 & **625** .4
Tramway & Railway World, May, p. 374.

City and South London Railway. (2,800 words, 1 table & fig.)

In Italian.

Giornale del genio civile. (Roma.)

1907 **62**. (01 (06.3
Giornale del genio civile, aprile, p. 173.

Congresso dell' Associazione internazionale per la prova dei materiali. (14,000 parole & fig.)

1907 **625** .24 (06.4
Giornale del genio civile, aprile, p. 221.

Vetture e carri da merci alla Mostra ferroviaria di Milano. (4,800 parole.)

Ingegneria ferroviaria. (Roma.)

1907 **621** .335
Ingegneria ferroviaria, nº 9, 1º maggio, p. 145.

I locomotori gruppo 3 6 delle ferrovie elettriche valtellinesi. (1,500 parole & fig.)

1907 **621** .133.7
Ingegneria ferroviaria, nº 10, 16 maggio, p. 154.

MELE (V.). — Un epuratore per caldaie da locomotive. (3,300 parole & fig.)

1907 **625** .216
Ingegneria ferroviaria, nº 10, 16 maggio, p. 160.

Calcolo dei respingenti dei veicoli per ferrovie. (2,200 parole, 1 tavole & fig.)

Rivista generale delle ferrovie e dei lavori pubblici. (Firenze.)

1907 **351** .812.1 (.45)
Rivista generale delle ferrovie, nº 19, 12 maggio, p. 289.

L'ordinamento delle ferrovie di Stato. (2,500 parole.)

In Spanish

Gaceta de los caminos de hierro. (Madrid.)

1907 385 .113 (.493)

Gaceta de los caminos de hierro, nº 2640, 1º de mayo, p. 193.

Los ferrocarriles de Bélgica en el año 1905. (2,800 palabras & 2 cuadros.)

In Dutch.

Locomotief. (Rotterdam.)

1907 385 .15 (.492)

Locomotief, nr 31, 1 Mei, p. 241.

Staatsexploitatie onzer spoorwegen. (1,400 woorden.)

Vol. XXI. — No. 8. August, 1907. 12th Year of the English Edition.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[385 .61]

THIRD INTERNATIONAL CONFERENCE OF THE UNION FOR THE STANDARDIZING OF RAILWAYS.

The third meeting of the International Conference of the Union for the standardizing of railways.was opened at Berne by Mr. Müller, president of the Swiss Confederation, on May 6, 1907. Mr. Robert Winkler, director of the technical division of the federal department of posts and railways, and delegate of the Swiss State, acted as chairman, and the work was continued, under his able presidency, till May 18.

Fourteen of the seventeen States concerned were represented at Berne by sixty-four delegates.

The subjects for discussion at the Conference were divided into two classes : the first included all the questions connected with existing agreements and with the elaboration of new regulations; the second all those connected with investigations which only later on can serve as bases for future possible agreements.

The work was entrusted to four commissions. The first (revision of arrangements in force and of questions relative thereto) was presided over by Mr. Gölsdorf (Austria), constructional consultant, the second (loading gauge and limitations rendered obligatory by curves) by chief inspector de Birly (Hungary), the third (maintenance of rolling stock and the loading of goods wagons) by chief inspector Radaelli (Italy); the business of the fourth commission, presided over by Mr. Dejaer, railway councillor (Belgium), was to consider various subjects of which the most important concerned the question of continuous automatic brakes on goods trains. Their proposals as accepted or amended at the general meetings, formed the basis of the final report, which was signed on May, 18, 1907.

Existing arrangements have been materially improved, particularly as regards the introduction of rules dealing with the state of maintenance of the rolling stock and with the loading of wagons. The report of May 1886 (date of the second conference) did not touch upon these points. These important stipulations are contained in articles III and IV of the final report of the conference. They form, together with the modifications introduced into articles I and II, the most important part of the new convention.

One subject before the meeting, was the question of adopting a universal standard loading-gauge. The Conference recognized the utility of having such a standard; and, in order that the question might be brought to a head before the next International Conference, the wish was formulated that the Federal Council should ask the other governments if they were prepared to appoint an international commission to investigate the subject and draw up a scheme.

The Conference also considered the question of automatic couplers. It concluded that as yet no existing pattern of automatic coupler had been proved, by sufficiently prolonged trial, to satisfy all requirements, and that, therefore, it was not yet necessary to propose that the European managements should give up the coupling systems at present in use. It decided that the time had not yet come to arrive at any definite conclusion as regards any such coupler.

The Conference also considered several points applying more especially to passenger stock : standardizing the connections of brakes and of heating apparatus, the lighting apparatus, the direction in which windows and doors are to be opened, types of vestibule connections, the exclusive use of bogie carriages in high-speed trains, etc. It concluded that all questions affecting directly only the comparatively small number of carriages passing from one country to another (the subject of special agreements between the managements concerned), should be dealt with in this way, and not made subject matter for insertion in the final report.

As regards the exclusive use of bogie carriages in high-speed trains, as the final report reserves to each State the right (art. II, § 1) of admitting only such vehicles in trains subject to special regulations, the Conference thought that this right could not be limited, and that consequently the exclusion of non-bogie stock was a question for mutual agreement between the managements concerned.

Finally, the Conference considered the further proposals made by the German and Belgian governments on the important question of equipping goods trains with continuous brakes.

The proposal of the German government was that the participating States should be requested to organize trials, on a large scale, of goods trains equipped with continuous brakes.

The supplementary proposal of the Belgian government set forth certain considerations tending to demonstrate the necessity, in order to make such future trials truly comparable, of determining the definitive bases on which such trials should be made.

Recognizing the advantage of having goods trains equipped with a continuous automatic brake, and the great advantage which would result, in the case of international traffic, if systems of brakes which could co-exist in the same train were adopted, the Conference decided that there are already in existence systems of brakes which it is hoped can be used on goods trains, but that none of them as yet appears to be quite suitable for this special purpose; that in order to bring the matter to a head, it would be advisable to draw up a programme to guide the managements undertaking the trials.

After discussing the desirability of such a programme and how it should be formulated, the Conference unanimously passed the following resolution :

The Conference requests the Federal Council to ask the other governments if they are prepared to appoint an international commission to draw up the programme of the trials to be made, by the different managements, of equipping goods trains with continuous brakes.

The customs agreement adopted in 1886 was only modified in some particulars of no great importance.

The session was concluded by a banquet given to the delegates by the Swiss Federal Council. Mr. Müller, president of the Confederation, greeted the members of the Conference on behalf of the Federal Council. Count d'Aunay, minister of France, replied for the diplomatic body; Mr. de Misani, delegate of the German government, proposed the toast of " prosperity to the Swiss Confederation "; and Mr. Worms de Romilly, delegate of the French government, warmly thanked the Federal Council, the Railway Department and the Administration of the Federal Railways, and the other Swiss railway managements.

We give below the two reports of the International Conference of the Union for the standardizing of railways, on the rolling stock and on the closing of wagons to pass in bond.

FINAL REPORT

OF THE

THIRD INTERNATIONAL CONFERENCE OF THE UNION FOR THE STANDARDIZING OF RAILWAYS.

Berne, May 18, 1907.

Art. I.

Gauge of the line.

	Maximum	Minimum
	dimension in millimetres (in feet and inches).	
The **gauge of the track** of railways, measured from inside to inside the rail-heads, in the case of new tracks and of tracks which are being renewed, is not to be less than . . . . on straights,	...	1,435 ($4' \, 8 \, {}^{17}/_{32}''$)
and on curves, superelevation included, it is not to exceed	1,470 ($4' \, 9 \, {}^{7}/_{8}''$)	...

Art. II.

Construction of rolling stock.

§ 1.

[1] The rolling stock of railways cannot be excluded from international circulation on account of any of the particulars of construction referred to in the present report, as long as it satisfies the conditions specified below.

[2] There is, however, no obligation that cars should be admitted in trains the composition of which is controlled by special regulations, if the cars in question do not satisfy the requirements of such special regulations.

[3] The maximum and minimum dimensions specified below apply both to new stock which is going to be constructed, and also to old stock, subject to the limits specified, in the latter case, in brackets.

	Maximum	Minimum
	dimension in millimetres (in feet and inches).	
§ 2.		
1 **Extreme distance between axles** of new cars . . .	...	2,500 (8′ 2 7/16″)
2 This rule does not apply to bogie stock.		
3 Cars in which the extreme distance between axles does not exceed 4,500 millimetres (14 ft. 9 1/8 in.), are admitted on all lines open to international traffic.		
4 The extreme distance between axles is not limited in the case of bogie stock. The same is the case with other stock in which the axles have sufficient radial movement to enable them to run over curves having a radius of 150 metres (7 1/2 chains). The latter cars shall be marked with the sign ←⊖→ when the extreme distance between axles exceeds 4,500 millimetres (14 ft. 9 1/8 in.) (*see* appendix *A*).		
5 Any regulations of railway managements on the subject of the greatest distance between axles of cars not satisfying the conditions laid down under 3 and 4, must be communicated to the States participating.		
6 When more than two axles are fitted under one and the same underframe, and the distance between the axles furthest apart exceeds 4,000 millimetres (13 ft. 1 1/2 in.), the axles must have sufficient radial movement to enable them to run over curves having a radius of 150 metres (7 1/2 chains) without difficulty.		
§ 3.		
Distance between the two wheels of one axle, measured between the insides of the tires or the parts corresponding	1,366 (4′ 5 13/16″)	1,357 (4′ 5 7/16″)
§ 4.		
1 **Width of the tires** on parts corresponding . . .	150 (5 29/32″)	130 (5 1/8″)
2 Minimum admitted in the case of stock already existing, subject to the condition that the distance between the wheels (§ 3) is at least 1,360 millimetres (4 ft. 5 9/16 in.).	...	(125) [4 29/32″]
§ 5.		
Distance between the flanges, outside, measured 10 millimetres (3/8 inch) below the rolling circles which are assumed to be 1,500 millimetres (4 ft. 11 in.) apart.	1,425 (4′ 8 1/8″)	1,405 (4′ 7 5/16″)

	Maximum	Minimum
	dimension in millimetres (in feet and inches).	
§ 6.		
Depth of the flanges, measured vertically from the top of the rails, the wheels being in the normal position on a flat straight track	36 (1 $^{13}/_{32}$″)	25 (1″)
§ 7.		
Thickness of the tires of the wheels, measured in the plane of the rolling circle (§ 5)	...	25 (1″)
§ 8.		
Chilled cast iron wheels are admitted under goods wagons not fitted with brakes.		
§ 9.		
1 The two ends of the underframes of all cars must be fitted **with elastic buffing gear and drawgear.**		
2 This regulation does not apply to cars used for special transports.		
§ 10.		
1 **Height on buffers** measured vertically from the top of the rails to the centre of the buffers :		
empty cars	1,065 (3′ 5 $^{5}/_{16}$″)	...
cars with maximum load	...	940 (3′ 1″)
2 Dimensions admitted in the case of stock built before 1887 :		
empty cars	(1,070) [3′ 6 $^{1}/_{8}$″]	...
cars with maximum load	...	(900) [2′ 11 $^{7}/_{16}$″]
§ 11.		
1 **Distance between buffers**, centre to centre . . .	1,770 (5′ 9 $^{11}/_{16}$″)	1,710 (5′ 7 $^{5}/_{16}$″)
2 Dimensions admitted in the case of stock built before 1887	(1,800) [5′ 10 $^{7}/_{8}$″]	(1,700) [5′ 6 $^{15}/_{16}$″]
§ 12.		
1 **Diameter of buffer plates.**	...	340 (1′ 1 $^{3}/_{8}$″)
2 Dimensions admitted in the case of stock built before 1887	...	(300) [11 $^{13}/_{16}$″)
3 In the case of cars where the distance between the buffers is less than 1,720 millimetres (5 ft. 7 $^{11}/_{16}$ in.), the horizontal diameter of the buffer plates must be at least 350 millimetres (1 ft. 1 $^{13}/_{16}$ in.).		

	Maximum	Minimum
	dimension in millimetres (in feet and inches).	
§ 13.		
1 **Free spaces at the ends of cars,** on both sides of the draw-gear, between this, the buffer plates and any fixed parts projecting from the headstock at any point:		
Width	...	400 (1′ 3 3/4″)
Length, the buffers being driven home	...	300 (11 13/16″)
Height above the top of the rails	...	1,800 (5′ 10 7/8″)
2 No limit is fixed for existing stock.		
§ 14.		
1 **Projection of the buffers beyond the drawhook,** measured parallel to the centre line of the car, from the inside of the hook, not pulled, to the front of the buffers, not compressed	400 (1′ 3 3/4″)	300 (11 13/16″)
2 Dimensions admitted in the case of stock built before 1887:		
Carriages	(430) [1′ 4 15/16″]	...
Wagons	(430) [1′ 4 15/16″]	(223) [8 13/16″]
§ 15.		
1 **Length of the couplings,** measured from the front of the buffers, not compressed, to the inside of the furthest link, the coupling being opened to its limit (screw undone)	550 (1′ 9 11/16″)	450 (1′ 5 11/16″)
2 No limit is fixed for stock built before 1887.		
§ 16.		
Minor diameter of the section of the coupling link where in contact with the drawhook	35 (1 3/8″)	25 (1″)
§ 17.		
Safety coupling. Railway cars must be capable of being coupled up doubly, so that the safety coupling comes into use when the chief coupling breaks. Cars with central safety coupling must also be capable of being coupled up doubly to cars fitted with safety chains.		
§ 18.		
1 **Any part of the coupling which can drop** to below 130 millimetres (5 1/8 inches) above rail level, must be capable of being raised or hung so as to be kept at at least that height.		
2 In the case of existing stock, this rule shall come into force on January 1, 1912.		

§ 19.

All cars must be fitted with **bearing springs.**

§ 20.

Brakes must be arranged so that they are put on when the handle is turned to the right, that is to say, is turned in the direction in which the hands of a clock move.

§ 21.

[1] **Projection of look-outs or other projecting parts on the front of the cars** beyond the front of the buffers driven home, measured along the centre line of the car.

Maximum	Minimum
dimension in millimetres (in feet and inches).	
...	40 (1 $^{9}/_{16}$″)

[2] No limit is fixed for existing stock.

§ 22.

The dimensions of the cross-section of the cars must satisfy the regulations of the Administrations of the lines on which the cars are to run. These regulations are to be communicated to the States concerned.

§ 23.

The **locks of passenger carriages used for international traffic** must, in so far as the doors of such carriages are fitted with key-locks, be openable with one or the other of the two forms of key shown in appendix *B*.

§ 24.

[1] **Outside sliding doors** must be constructed so that they cannot drop.

[2] Those of existing wagons must at least satisfy this condition when closed.

§ 25.

Each car must on each side bear an **inscription** showing :

1. The railway owning it or in whose books it is entered;
2. The index number;
3. The tare or net weight, wheels and axles included. In the case of wagons however with axles which have to be changed on account of break of gauge, only the weight of the hung part is inscribed on the body, and that of the axles, fitted, on the axle-boxes;

4. In the case of wagons and luggage vans, the normal load and the load limit, or only the normal load. Where there is only one inscription, that represents the normal load. In this case, the load limit shall be 5 per cent more than that figure;
5. The distance between the axles furthest apart, or, when the car is on bogies, the distance between the bogie centres, and the maximum wheelbase of each bogie;
6. When required, the sign ←⊖→ specified under § 2 (*see* appendix *A*);
7. The date of last general overhaul;
8. In the case of cars with periodical lubrication, the period of the lubrication and the date when last lubricated;
9. In the case of privately owned cars, the sign $\boxed{\text{P}}$, placed after the index number.

Maximum	Minimum
dimension in millimetres (in feet and inches).	

Art. III.

State of maintenance of rolling stock.

§ 1.

[1] Cars used for international traffic must be kept in a proper state of maintenance so as in no manner to imperil the safety of the working.

[2] If that is not the case, and, more especially, if the cars do not satisfy the conditions specified under §§ 2 to 4, or if they show one of the defects enumerated under § 5, they can be refused.

§ 2.

When a car passes over on to the system of an adjoining country, the time which has elapsed since the last general overhaul must not exceed three years. All cars however, whether loaded or not, still capable of running and returning to their home country, must be accepted by the managements of intermediate lines, even if a longer time has elapsed.

§ 3.

[1] The axle-boxes must be filled with suitable lubricating material.

[2] Cars with periodical lubrication, if the period of lubrication has elapsed, may not leave the railway owning them without fresh lubrication.

§ 4.

Wagons used for the transport of cattle must be returned perfectly cleaned and disinfected.

§ 5.

Defects justifying refusal :

A. — Defects in the wheels and axles.

1. Wheels showing any signs of having shifted on their axle.

2. Wheels having their centre cracked without being loose.

3. Wheels with their rims broken across and having tires less than 30 millimetres (1 $^3/_{16}$ inch) thick at the rolling circle. Any commencing fractures at the rim, are not causes for refusal.

4. Wheels having a spoke broken across, or more than one spoke cracked, and wheels with cast iron centres in which the majority of the spokes are out of true.

5. Solid wheels having a circular crack extending over more than one fifth of the circle in which they are located, or having more than two radial cracks.

6. Cast iron wheels without tires, showing any cracks. Slight lines on the tread, as well as unimportant defects in the body of the wheels resulting from the operation of casting, are not causes for refusal.

7. Wheels having flanges less than 20 millimetres ($^{25}/_{32}$ inch) thick at the points where they touch the rails; wheels having a cutting flange, that is to say when there has been so much wear that a sharp edge has been formed. In the case of cars with three axles, the thickness of the flanges of the middle wheels is not taken into consideration.

8. Wheels with treads showing flats having a sagitta of more than 5 millimetres ($^3/_{16}$ inch).

9. Wheels with tires which are crushed, broken, cracked across or cracked along the circumference.

10. Wheels with separate tires, when :

   a) The tires are loose or show signs of lateral displacement;

   b) More than two of the bolts, screws or rivets fixing the tire to the rim are broken, displaced or lost;

   c) If secured by means of Mansell rings :

      1 When the sides or even the treads themselves show cracks more than 100 millimetres (3 $^{15}/_{16}$ inches) long;

      2 When more than two of the bolts securing the rings are broken.

11. Axles out of true or showing cracks or commencing fractures.

12. Axles on which the draw-rods of brakes or other parts rub. If the rubbing pieces can be removed and if the wear does not extend deeper than 2·5 millimetres ($^3/_{32}$ inch) (5 millimetres [$^3/_{16}$ inch] on the diameter) and there are no sharp corners, the car must be accepted.

B. — Defects in the axle-boxes and bearings.

1. Axle-boxes so damaged that they cannot guide the axle properly or cannot hold the lubricating material.

2. Bearings which have become seriously heated.

C. — Defects in the bearing springs.

1. Displacement, of more than 20 millimetres ($^{25}/_{32}$ inch), of a spring or of its back plate relatively to the axle-box when the distance between the axles furthest apart does not exceed

4,500 millimetres (14 ft. 9 $^1/_8$ in.), and of more than 5 millimetres ($^3/_{16}$ inch) when that distance is greater.

2. Fracture of the back plate of a bearing spring.

3. Fracture of an intermediate plate near the middle, in the case of passenger stock; and fracture of two or more intermediate plates near the middle, in the case of goods stock.

4. Fracture of a helical spring not kept in position by a stop or a bolt passing through it.

5. Absence or fracture of the parts necessary to fix the springs.

6. Body or sole bars of underframe bearing on the buckle of the bearing spring, rubbing against the wheels, or showing recent traces of such contacts. Old traces of former contacts or the contact of safety supports with the outer fourths of the length of the spring do not justify refusal.

N. B. — Cars in which the distance between the axles furthest apart does not exceed 4,500 millimetres (14 ft. 9 $^1/_8$ in.), and returning, empty, to the system owing them, must be accepted if they have the defects specified under C, 2 to 6, provided that they are suitably and firmly secured.

D. — Defects in the buffing gear.

1. Rods or springs of buffers broken or damaged so as to prevent the buffers from working.

2. Absence of the parts which prevent the buffers from dropping.

3. Buffer boxes broken or missing. Buffer boxes which, although damaged, still support and guide the buffers sufficiently, are not causes for refusal.

N. B. — Cars returning empty to the system owning them, must be accepted if they have the defects specified under D, 1 to 3, if they can run without danger at the tail end of a train.

E. — Defects in the draw-gear.

1. Chief couplings or safety couplings or chains broken, draw-hooks broken or showing signs of fracture when the regulation coupling up with other cars (including both the chief coupling and the safety coupling) becomes impossible.

2. Drawbars, pins and guides broken or showing signs of fracture.

3. Absence of safety chains or of safety couplings in the case of cars not equipped so that the two chief couplings of the two cars in contact can be used simultaneously.

4. Helical drawsprings broken, or plate drawsprings with the back plate broken at any point, or one of the other plates broken near the middle.

N. B. — Cars returning empty to the system owning them, must be accepted if they have the defects specified under E, 1 to 4, if they can run without danger at the tail end of a train.

F. — Defects in the underframe and body of cars.

1. Axle-guards broken or cracked through more than one third of their section, also displaced axle-guards, if they cannot be adjusted by tightening the bolts.

2. Sole bars, headstocks and any intermediate cross-framing in connection with the draw-gear, broken across.

3. Parts of the frame of the body broken right through, any damage at the doors, locks, sides of the body, flooring and roof, if such damage may result in the deterioration of the load or may endanger the safety of the working.

N. B. — Cars returning empty to the system owning them can only be refused on account of damage to the underframe, if running such cars would entail danger.

§ 6.

Cars with brakes which are damaged or do not act, cannot be refused, but they must bear conspicuous labels with very clear lettering stating that the car is not available for braking. Damaged or loose parts which might endanger the safety of working or cause other damage, must be taken off.

§ 7.

Empty returned cars must be accepted by the system owning them, no matter what their condition may be; in the case of cars which have been used for cattle, however, this acceptance is not compulsory until after the cars have been perfectly cleaned and disinfected.

ART. IV.

The loading of the wagons.

§ 1.

Wagons used for international traffic cannot be refused if the load is in a satisfactory condition which in no way can endanger the safety of working, and if it more particularly satisfies the following conditions :—

§ 2.

The articles loaded on wagons must be arranged and stowed so that they cannot shift, even in case of shock or shaking.

§ 3.

[1] The load must be distributed as equally as possible over all the wheels of the wagon, particularly as regards the end wheels.

[2] Wagons with the load so unequally distributed that the body or sole bars touch the buckles of the bearing springs, or that it makes them rub against the wheels, can be refused.

§ 4.

The load in a wagon must not exceed the load limit. When no load limit is inscribed on the wagon, an overload of 5 per cent in addition to the normal load inscribed on the wagon, is allowed.

§ 5.

[1] The weight per wagon wheel (the wheel-load) must not exceed the maximum allowed on each line.

[2] The regulations of the managements of each line must be communicated to the States participating.

§ 6.

[1] The load on open wagons must not project beyond the loading gauge used on the different systems. The width of long loads must be reduced so as to allow for running round curves of small radius.

[2] The regulations of the managements of each line must be communicated to the States participating.

§ 7.

[1] The load on open wagons must not project beyond the headstock unless there is, between the load and the plates of the buffers not compressed, a space of at least 400 millimetres up to 2,000 millimetres (1 ft. 3 $^3/_4$ in. up to 6 ft. 6 $^3/_4$ in.) above rail level, and of at least 200 millimetres (7 $^7/_8$ inches) higher up. Moreover, in order to allow coupling up to be effected, there must be a completely clear space at least 200 millimetres (7 $^7/_8$ inches) in height above the draw-hook, and at least 200 millimetres (7 $^7/_8$ inches) wide on each side of the centre line of the hook.

[2] If the load projects further beyond the headstock than here specified, a safety truck must be added.

§ 8.

For loading up long articles which cannot be carried on one single wagon, two wagons equipped with swing bolsters must be used. The wagons may be connected by screw couplings, by an iron coupler bar or a wooden coupler bar properly strengthened by iron, by an intermediate truck connected with the two carrying wagons by coupler bars or couplings; or finally by the load itself if it can be used for the purpose and if each swing bolster is supporting a weight of at least 7·5 tons. The load must rest on the swing bolsters only; it must project beyond them at least 300 millimetres (11 $^{13}/_{16}$ inches), and at least 1,000 millimetres (3 ft. 3 $^3/_8$ in.) if the load alone connects the wagons.

§ 9.

[1] If safety trucks or intermediate trucks are used, the load must be located at the following distances :

a) From the floor of the said trucks :
   at least 100 millimetres (3 $^{15}/_{16}$ inches).

b) From the longitudinal sides of the safety trucks, unless the tops of the sides are at least 100 millimetres (3 $^{15}/_{16}$ inches) lower than the bottom of the load :
   at least 300 millimetres (11 $^{13}/_{16}$ inches) if the load does not extend beyond the middle of the truck ;
   at least 500 millimetres (1 ft. 7 $^{11}/_{16}$ in.) when it does extend beyond the middle of the truck.

c) From the longitudinal sides of the intermediate trucks, unless the tops of the sides are at least 100 millimetres (3 $^{15}/_{16}$ inches) lower than the bottom of the load :
   at least 500 millimetres (1 ft. 7 $^{11}/_{16}$ in.), when the distance between the swing bolsters of the wagons does not exceed 20 metres (65 ft. 7 in.); when the distance between the swing bolsters of the carrying wagons exceeds 20 metres (65 ft. 7 in.), the tops of the sides of the intermediate trucks must always be at least 100 millimetres (3 $^{15}/_{16}$ inches) lower than the bottom of the load.

[2] These spaces must not be reduced by loading up other articles in them.

[3] The use of more than one intermediate truck is not allowed.

ART. V.

When any improvements or modifications in the preceding articles appear desirable, new conferences can be held, at the request of one of the States participating, the notices calling the meeting being issued by the Swiss Federal Council.

ART. VI.

[1] The States which have not yet adopted the rules of the Union for the Standardizing of Railways are at liberty to join the Union.

[2] If so, they must give notice to the Federal Council, and the latter will inform the other States represented at the Conference of the fact.

[3] By doing so, they become fully bound to observe all the rules, and entitled to all the advantages specified in those rules.

ART. VII.

The governments concerned will inform the Federal Council before January 1, 1908, what determinations they have arrived at with reference to the present rules.

ART. VIII.

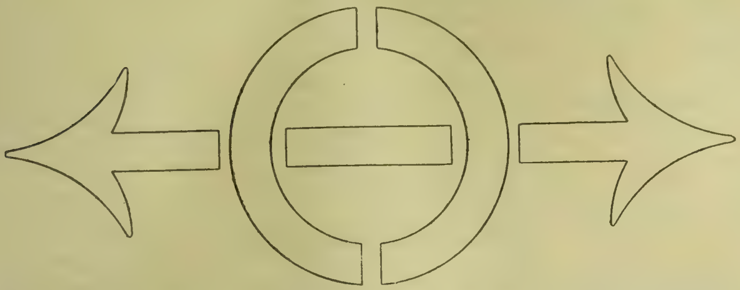
When the States have notified their determinations, and at the latest on February 1, 1908, the Swiss Federal Council will propose to the governments participating a date when the present rules are to come into force.

ART. IX.

Each signatory State has the right to withdraw from the Union, subject to notice given by its government, six months in advance, to the Swiss Federal Council.

Appendix A

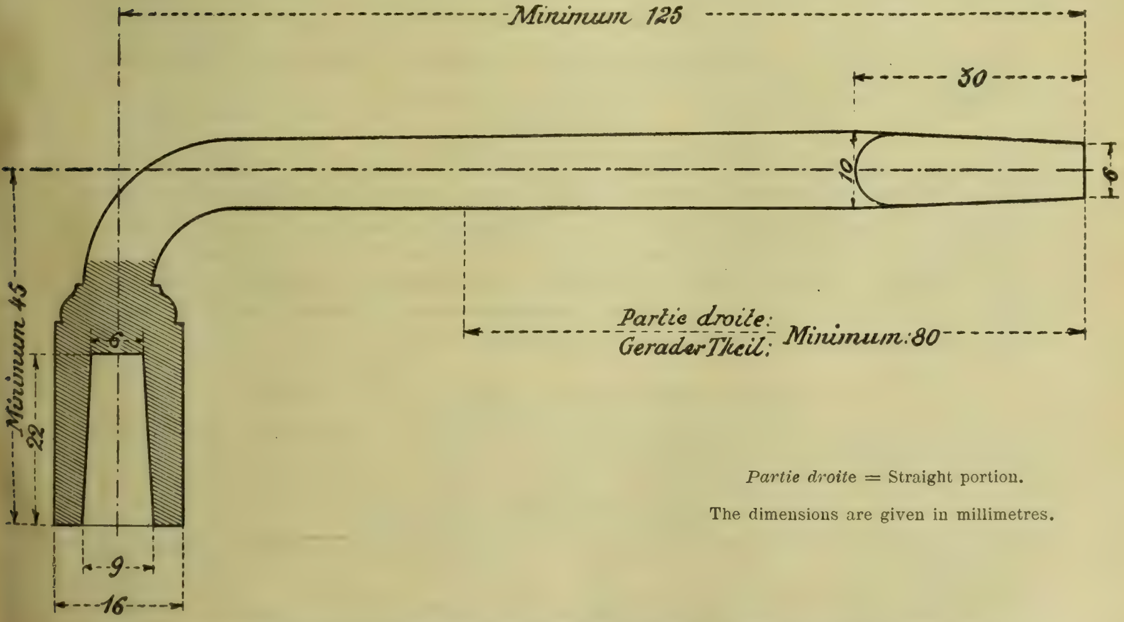
to the final report of the third International Conference of the Union for the Standardizing of Railways, of May, 18, 1907.



Sign for marking cars as specified in article II, § 2, No. 4. — Scale, one half.

Appendix B

to the final report of the third International Conference of the Union for the Standardizing of Railways, of May, 18, 1907.



Partie droite = Straight portion.

The dimensions are given in millimetres.

Double key for carriages used for international traffic, as specified in article II, § 23. — Actual size.

FINAL REPORT

ON THE

CLOSING OF WAGONS TO PASS IN BOND.

Berne, May, 18, 1907.

Art. I.

A. — General arrangements.

Wagons and compartments of cars used for the carriage of goods and luggage in bond, must be constructed so that they can be closed easily and effectively, so as to prevent the possibility of goods or luggage enclosed in the loading space from being removed or exchanged without breaking it open, or without leaving visible traces of tampering.

In wagons or compartments of cars of this kind there must be not hidden or difficultly accessible space which can contain goods or luggage.

Each wagon must bear on each of its two long sides an inscription of the name of the owner and a number. Where cars have several separate compartments, each of the latter must be marked by a letter.

B. — Special arrangements.

In order to guarantee the efficiency of the closing of these cars, the following conditions must be satisfied :

1. — Car bodies.

The side walls, the floor, the roof and all the parts of the car which form the compartment intended to hold goods or luggage, must be fixed in such a manner that it is impossible to undo them from the outside and replace them without leaving visible traces thereof.

All such parts must be in good condition.

Any eventual damage to the walls of cars does not render such cars unsuitable for a transport of this kind, unless it is to be feared that the openings resulting from such damage are such as to allow access to be obtained to the contents of the car.

2. — Clearance between the sliding doors and the walls of cars.

The clearance between the closed sliding doors and the body of covered wagons must in no case exceed the maximum of 20 millimetres ($^{25}/_{32}$ inches).

3. — Appliance for closing sliding doors.

Each sliding door of a car must be fitted with a hook and pin or other appliance, for closing, of equal efficiency.

These appliances must be so fixed that when the doors are closed it is impossible to remove them without violence and without leaving visible traces thereof.

4. — Pins for the customs fastening.

The sliding doors, the swinging doors, the doors in the end walls, in fact all the available doors of covered wagons, as well as the openings for filling and emptying tanks on wagons (tank trucks), must be provided with pins made of bar at least 15 millimetres ($^{19}/_{32}$ inches) in diameter, or with other fittings which enable customs padlocks and customs leadseals to be applied in such a way that it is impossible to open the doors or the openings for filling or emptying, without breaking the fastening applied by the customs.

These pins or other fittings must be secured to the wagon by means of rivets, or of bolts with the nut inside so as not to be accessible once the door is closed.

5. — Safety fastening of sliding doors.

The lower part of the door must be fitted with a safety fastening which makes it impossible to lift the sliding door from the rail on which it runs.

This appliance can consist, for instance, of a hook which when the door is closed hooks into a pin riveted to the rail, or of a continuation of the iron framing of the door to below the rail head or to below the rail itself, or of an angle or buckle riveted to the rail, etc. As an exception the safety fastening may consist of an iron fitting with holes which allow customs padlocks and customs leadseals to be used. The bearing rollers must be fixed so that they cannot be removed without violence.

6. — Rails of sliding doors.

The rails of sliding doors must be riveted to at least two of their supports. The latter must themselves be fixed to the body of the car in such a way that they cannot be unfixed without violence and without leaving visible traces thereof.

7. — Guidance of top of sliding doors.

Sliding doors must be guided at their upper part by bars or rails properly fixed to the car.

8. — Swinging doors and end doors.

In the case of covered wagons with swing or drop doors (beer vans for instance), or with doors in the end walls, such doors must, in addition to the fastenings and fittings which cannot be removed from outside, be supplied with an appliance for the customs fastenings satisfying the conditions specified under No. 4, so that they cannot be opened without violating the customs fastening.

The end doors not used (for instance in the wagons arranged with a view to ambulance service) must be permanently closed by a covering, by rods or by iron bars so as to secure them properly from the customs point of view.

9. — Windows and openings for ventilation.

When the openings made in covered wagons, such as windows and openings for ventilation, are secured by bars, screens or perforated plate, the clear openings remaining must not exceed 30 square centimetres (4·65 square inches), so that the contents of such wagon cannot be removed through the openings. None of the pieces fixing such screens must be capable of being undone from outside the wagon.

If the openings in question are not closed by screens, but by sliding or swinging shutters, these latter must be secured as follows :

swing shutters or shutters with horizontal slides, by hasps, bolts, hooks, pins or other similar fastening;

shutters with vertical slides, by any of the fastenings just enumerated or by a customs fastening such as specified under No. 4, that is to say, by customs padlocks or by string lead-sealed with customs seals;

so that it is not possible to open the shutters from the outside without violence or without leaving visible traces thereof, or without breaking the customs fastening.

Drainage holes in the floor must be covered with screens, if their diameter exceeds 35 millimetres (1 $^5/_8$ inch).

10. — Receptacles on the roof of wagons.

In the case of receptacles on the roof of wagons, closed by shutters or covers, as regards the securing of these latter the rules specified under the preceding numbers, are to be observed.

11. — Wagons with non-continuous walls or floors.

Wagons with non-continuous walls or floors (such as cattle trucks for instance), but which otherwise satisfy the conditions mentioned above, can only be used for the carriage of packages of such a nature that it is impossible to remove such packages or part or the whole of their contents through the openings. More especially, liquids and goods in grains or powder may not be carried in such wagons, even if enclosed in barrels or in sacks.

12. — Open wagons partly covered in by fixed covers.

Open wagons, the end walls of which are connected by a strong bar, and partly covered by fixed covers at least 75 centimetres (2 ft. 5 $^1/_2$ in.), wide, and having side walls at least 50 centimetres (1 ft. 7 $^{11}/_{16}$ in.) high, can, if equipped with rings for securing the sheets, be used with the latter for the carriage of goods of all kinds liable to duty.

13. — Other open wagons.

Other open wagons equipped with rings or other devices for securing the sheets, can be used for the carriage of goods passing in bond, if the goods consist of packages weighing at least 25 kilograms (55 lb.) each, or of articles which can hardly be loaded or are not usually loaded in covered wagons or in the open wagons specified under No. 12, either on account of size (large machinery, parts of machines, steam boilers, etc.), or on account of their nature (timber, cotton, coal, coke, sand, stone, ore, cast iron, scrap iron of all kinds, iron bars, cattle, herrings, fish oil, petroleum, etc.).

In the special case here considered, it is left to the discretion of the custom house authorities to decide, in accordance with the instructions given to them by the higher authorities, whether, in order to prevent the removal or exchange of such goods, it is necessary to cover them with a sheet, to fix on lead seals or to take any other measures for securing them, or whether finally as an exception no cover shall be used nor other measures be taken for ensuring that the goods remain unchanged. The authorities concerned can also have such goods accompanied.

The instructions issued by the higher authorities of each State, for the purposes of the preceding paragraph, are to be communicated to the others States concerned.

14. — Sheets and the method of securing them.

The rings for securing the sheets must be closed and welded, and fastened from the inside of the wagon by eye rivets or eye bolts, and spaced not more than 115 centimetres (3 ft. 9 $^5/_{16}$ in.) apart, nearly at the same level as the floor of the wagon, and that either to the movable side walls or to the doors and to the headstocks alternately, or else to the underframe itself, so that the cord used prevents the movable walls from being removed or the doors from being opened, if such are present.

The sheets must have along their edges holes with metal eyelets inserted, through which the cord used passes; the eyelets must be spaced at approximately the same distances as the rings fixed to the wagons. Rings fixed to the sheet may only be used for securing the upper part of the sheet.

The sheets must be sufficiently large and in a condition suitable for the desired purpose. Seams must in all cases be inside, or be double, that is to say consist of two rows of stitches 15 to 25 millimetres ($^5/_8$ to 1 inch) apart.

The securing cords must consist of one single length, and be provided at each end with metal points. Behind these points there must be eyes, so that when the ends of the cord have been properly and securely knotted, the customs fastening can then be applied.

ART. II.

The governments concerned will inform the Federal Council before January 1, 1908, what determinations they have arrived at with reference to the specifications contained in article I.

ART. III.

This convention shall come into force three months after the day on which the Federal Council informs the governments concerned that it has been definitely accepted by all the States concerned.

ART. IV.

Each State concerned reserves the right of proposing at any time to the Federal Council that the rules agreed to should be revised, stating the reasons for its proposals, and stating at what date it would desire the consequent negociations to be opened.

If no agreement is arrived at, the State making the proposal will have the right of no longer considering itself bound by this convention, as soon as a period of six months has elapsed, such period to begin at the date proposed for the opening of the negociations.

[621 .55]

REPORTS

OF THE

SWISS COMMISSION FOR STUDYING THE ELECTRIFICATION OF THE RAILWAYS,

By Professor Dr. W. WYSSLING,

GENERAL SECRETARY OF THE COMMISSION.

(*Schweizerische Bauzeitung.*)

(*Abstract.*)

Quantity of power required to operate the Swiss railways by means of electric traction.

One of the principal items in the programme adopted in May 1904 by the commission, was the determination of the quantity of power required to operate the whole of the Swiss railways electrically. In Switzerland, the utilization of certain technical advantages which electric traction is credited with, and which in many cases has led to the adoption of this system of traction (greater speed, possibility of coping with more traffic, absence of smoke, etc.), is not the most important factor in the electrification of railways; there, on the contrary, the economical side of the question is of paramount importance; in other words, the substitution of native waterpower for coal imported from abroad.

The first question that then arises is : How much energy is required, and does that amount exist in the country?

As somewhat pessimistic figures as to our waterpower resources had been compiled some years ago, this question not only arose in the minds of those little conversant with the subject, but also had to be carefully considered by experts, seeing that some of the existing waterpowers were not suitable for railway purposes.

The answer to the first point involved — how much power is required — depended to some extent on what electro-mechanical system was selected. But the quantity of energy required depends at least as much, if not more, on the technical organization proper. Nevertheless it was possible to obtain a sufficiently approximate solution of this question by establishing the relation between the quantity of energy and the work developed at the driving wheels of the vehicles; the latter being but little affected by the electro-mechanical system selected. As regards the organization of the train service, in the beginning it will no doubt be necessary, particularly in the case of the through train services with other countries, to keep to the time-tables of the existing steam services, and to continue doing so probably for a very long time; but these through services only include comparatively few but heavy trains. If the present time-tables are taken as a basis, we in any case obtain the highest figures for the quantity of energy required, which can occur when electric traction is used.

This hypothesis being accepted, it was then decided what fundamental conditions the new service should satisfy from the technical point of view. The whole investigation was conducted by a sub-commission consisting of engineers of our chief railways and of electricians; this sub-commission entrusted Mr. L. Thormann with the execution of the calculations and the collection of the detailed data required, while they themselves discussed the results obtained and determined further procedure. In this note, we shall give an abstract of Mr. Thormann's very complete report, and we shall begin by explaining the assumptions made.

Rolling resistance (coefficient of traction). — The rolling resistance, by which we mean (using the word in an enlarged sense) all the resistances opposing the movement of a train at a uniform speed on the flat, includes : *a*) the friction resulting from the rolling, and sometimes from the sliding, of the wheels on the rails, including the additional resistance due to the presence of foreign bodies, of irregularities in the surface of the rails, etc.; *b*) the friction of the axles in the axle-boxes; *c*) the friction of the flanges of the wheels against the rails when running round curves; *d*) the resistance of the air (head resistance) and the friction between the air and the vehicles generally.

The first three items alone are practically proportional to the mass of the vehicles moving, the latter being assumed in each case to be of the same design. As for the total resistance of the air, this can only be determined experimentally; we also know that it depends on how the train is arranged.

The following were taken into consideration :

1° The experiments made during the high speed trials at Zossen in 1902-1903. The coefficient (in kilograms per ton) of the resistance of the air found was $\lambda = 0{\cdot}0052V^2F$, where V is the speed in kilometres per hour, and F the area of the front of the train in square metres;

2° Trials made by Mr. Davis on the Buffalo-Lockport line (*Street Railway Journal*, 1902) (^{1}), where similarly the result was $\lambda = 0{\cdot}0076V^2F$, with a coefficient of 3 kilograms per ton (6·7 lb. per English ton) for the friction of the axles and $0{\cdot}04V$ in kilograms per ton for the friction on the rails;

3° Trials made by Mr. Barbier on the French Northern Railway (*Revue générale des chemins de fer*, 1898) (^{2}), with the following results : With a train of fourteen vehicles, each having four wheels, and weighing 160 tons, the total rolling resistance, in kilograms per ton, $= 1{\cdot}6 + 0{\cdot}023V + 0{\cdot}00046V^2$, the head resistance of the air having been calculated by means of the equation $\lambda = 0{\cdot}0077V^2F$. Now the very accurate trials made at Zossen

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(1) See "Train resistance", by J. W. Davis Jr, in the *Bulletin of the Railway Congress*, July 1903, p. 637.

(2) See "Resistance to traction of rolling stock at high speeds", by F. Barbier, in the *Bulletin of the Railway Congress*, October 1898, p. 1275.

show that this figure is too high; therefore, the rolling resistances proper were greater in Mr. Barbier's experiments than he indicates. If Mr. Barbier's curve which represents the total rolling resistance on a straight track as a function of the speed, is correspondingly corrected, we obtain a curve which does not appreciably differ from that which can be deduced from the Zossen trials for a train of the composition mentioned above;

4° An older equation by Clark gives similar results.

Consequently the total rolling resistance, in kilograms per ton (in lb. per English ton), of a train consisting of 14 four-wheeled vehicles will be as follows:

Speed, in kilometres (in miles) per hour.	According to Barbier's corrected figures.	According to the Zossen trials (calculated).	According to Clark.
0	1·5 (3·4)	1·2 (2·7)	2·3 (5·2)
50 (31·0)	4·4 (9·9)	3·9 (8·7)	4·4 (9·9)
100 (62·1)	11·0 (24·6)	10·4 (23·3)	10·2 (22·8)

Different results are of course obtained with trains of different composition; the rolling resistance of bogie stock for instance is considerably less. But in such an investigation as the one in question, it was evidently impracticable to determine the rolling resistance of every individual train. Consequently, in order to determine the rolling resistance in kilograms per ton, we adopted, as a sufficiently accurate mean, Mr. Barbier's curve (corrected as described above) for fourteen four-wheeled vehicles. As bogie stock is largely used, the figures obtained will be rather higher than the true values.

The calculations would however have been too inaccurate if the figure used for the whole service had merely been the average corresponding to the average speeds of express trains, ordinary trains and goods trains, inasmuch as the different rolling resistances vary largely in their effect on the average (number of trains, tonnage). Therefore, what was in the first place calculated was the total amount of work required for hauling trains of the three kinds over each section of a fairly large railway system (division I of the Swiss Federal Railway), taking as basis the true train service as described below, and assuming the different trains to run in each case at speeds of 5 kilometres (3·1 miles) per hour less than the maximum authorized speed on the section in question. Finally, the total traction work was reduced to the ton-kilometre unit and it was thus found that the true mean rolling resistance was 4·3 kilograms per ton (9·6 lb. per English ton). This resistance varies in the different cases as follows: express trains, between 5 and 6·8 (between 11·2 and 15·2 lb. per English ton) (exceptionnally 4·5 [10·1 lb.]); ordinary passenger trains, between 4·5 and 5 (between 10·1 and 11·2 lb. per English ton (exceptionally 3 [6·7 lb.]); goods trains and optional trains, between 3 and 3·2 (between 6·7 and 7·2 lb. per English ton).

The resistance on curves was determined from the equation $w_c = \frac{650}{R - 55}$ kilograms per ton, which is generally adopted by railway men, and is deduced from Röckl's experiments (*Organ*, 1881). In this equation, R represents the radius of the curve in metres. Special statistics compiled show that the mean radius of curvature on the Federal Railway was about 1,500 metres (75 chains) and on the St. Gothard Railway about 970 metres (48 $^1/_2$ chains); the curve resistance corresponding to these radii being 0·5 and 0·7 kilogram per ton (between 1·12 and 1·57 lb. per English ton) respectively.

Taking the latter less favourable figure as basis, the total mean rolling resistance is 4·3 + 0·7 = 5 kilograms per ton (11·2 lb. per English ton). Nevertheless, in order to be on the safe side, 6 kilograms (13·4 lb. per English ton) were, at the suggestion of the railway engineers, allowed for in calculating the work, so as to allow for less favourable conditions.

As the more unfavourable figures were taken in every case, it can be asserted that the quantity of energy required in standard gauge lines has been more than fully allowed for, and that the real requirement will in any case certainly be less.

In the case of narrow-gauge lines, the total rolling resistance has been assumed to be 10 kilograms per ton (22·4 lb. per English ton); this figure is certainly also on the safe side.

In giving all these details as to the determination of the rolling resistance accepted as the basis of the computations, it was our intention to show by this example that the calculations were not made roughly, but were made with as much accuracy as possible, although this involved a very large amount of work.

Energy absorbed in starting and in braking. — Theoretically, the energy absorbed by a train while starting and until its maximum speed is attained could subsequently be utilized to overcome the rolling resistance on sections run over without motive power. Similarly on down grades gravity could be utilized for starting. But it has been found in practice that it is only when stopping on ascents of about 20 per mil, or steeper, that running without motive power can be applied to any appreciable extent, if the time and distance required for stopping are not to become unduly long; similarly, it is only on down grades of similar character that gravity can be practically utilized for starting the train and accelerating it to the speeds actually used (up to 100 kilometres [62 miles] per hour). Consequently in determining the mean energy used every day in starting, in the regular service, it was assumed that the whole energy corresponding to the total number of starts, for trains of average weight and for the maximum speeds authorized in each case, must be supplied to the trains, no deduction being made for starts on down grades or stops on up grades. The amounts so obtained for the starting have been increased, in the case of ordinary and goods trains, by 30 per cent, and in the case of express trains, by 110 per cent, in order to allow for energy lost through changes of speed en route and unforeseen starts and stops at signals and sections under repair; this increase is also intended to cover the energy (which however only represents a small percentage of that required for starting) used up in accelerating the rotating masses of the motors.

The weight of the trains. — This was determined in the following way: the Swiss Federal Railway had detailed and complete information on this subject available; especially the load tables of the traffic department. The tables of August 1903 were taken as basis in the case of express and ordinary trains, and those of October 1903 in the case of goods trains; the passenger trains are generally heaviest in August and the goods trains in

October (sometimes the goods trains are nearly as heavy in August). By taking these two maximums, we thus obtain the highest possible maximum in the year. The weights of the steam trains of these months were determined for each individual section of the four divisions of the Federal Railway, first taking the average of each train number after having added together the weights of all the trains which had run under that number, and then taking the average of all the train numbers belonging to the corresponding kind of train (express, ordinary, goods) on the same section. In the same way, the maximum weight of each train number was determined, and then from the maximums of the train numbers of one class the average maximum weight of the kind and section in question. To these weights, the weight of the driving machinery then was added. With this object, and assuming the minimum coefficient of adhesion to be one seventh, the adhesive weight necessary for the steepest gradient existing on the section in question, was determined and added to the weight as determined above. This adhesive weight corresponds to that of the locomotives now used, tender and stores excluded. If electric locomotives are going to be used, a similar amount must be allowed for their weight. If motor cars are used, it is possible that the additional weight due to the motor equipment will differ a little from that given above, but not sufficiently to affect materially the question of the quantity of energy required.

The figures so obtained were rounded off on the safe side. Then also it was assumed that the weights would be the same in both directions; although this is not always the case, the differences will nearly compensate each other, as the rolling resistance is the most important factor concerned on the Swiss Federal Railway.

In the case of the St. Gothard Railway, the company gave information as to the maximum and average train weights; from these, the weight of the steam locomotives now used was deduced and the real adhesive weight required added, determined as described above. In this case also, in calculating the quantity of energy required, it was assumed that the train running in each direction would have to be of the same weight.

The traffic of the other Swiss steam railways, both standard gauge and narrow gauge, only equals about 8 per cent of that of the Federal Railway and St. Gothard Railway taken together; consequently it was not necessary, in this case, to go into so much detail. By comparing the weights as determined above with the actual statistics of the trains hauled on the Federal and St. Gothard Railways during the year 1902, it was found that the averages shown in the statistics must be increased from 30 to 40 per cent in order to obtain the weights of the trains in August and October. The same increase was therefore made in the averages shown in the statistics of the other steam lines, and the figures so obtained were assumed to be the true weights of the trains in the months of most traffic (August and October).

The results obtained by these methods for determining the train weights are given, in round figures, in tons, in table I.

In winter, the weights of the trains are very much less on nearly all the Federal lines; they vary between 70 and 85 per cent of the August (passengers) and October (goods) weights.

Timetable. — The week-day service of summer 1904, including special trains, was taken as basis; this was the busiest known when the investigation was begun.

Table I.

—	In the busiest months, the following are the limits (in tons, round numbers) within which vary				Weight of trains, in tons, taken as basis for the calculations.	
	the weights of the trains			adhesive weight (according to gradient).	Average weight, for determining quantity of energy required.	Maximum weight, for determining maximum load.
	average.	average of heaviest.	absolutely heaviest.			
A. — Swiss Federal Railways.						
a) *Express trains :*						
1. Heaviest weight (few)	220 to 250	270 to 320	320 to 480	50 to 80	300 to 350	400
2. Average weight	100 to 240	170 to 290	230 to 480	40 to 60	180 to 300	300
3. Very light weight.	80 to 110	100 to 160	110 to 260	20 to 60	120 to 180	150 to 200
b) *Ordinary passenger trains :*						
1. Heaviest weight (few)	160 to 180 (209)	240 to 270 (380)	340 to 480 (514)	40 to 60 (45)	200 to 250 (350)	350 (450 in one case).
2. Average weight	80 to 210	150 to 270	200 to 380	25 to 40	120 to 200	200 to 250
3. Very light weight.	50 to 100 (40)	80 to 120 (50)	80 to 230 (50)	20 to 40 (25)	70 to 120 (65)	150 (75 in one case).
c) *Goods trains :*						
1. Heaviest weight (few)	270 to 420 (500)	420 to 550 (700)	500 to 900 (900)	50 to 90 (50)	350 to 450 (550)	600 (750 in one case).
2. Average weight	210 to 350	290 to 450	360 to 740	40 to 70	275 to 400	450
3. Very light weight.	40 to 180	50 to 300	50 to 350	20 to 60	65 to 300	75 to 300
B. — St. Gothard Railway.						
a) *Express trains :*						
1. As a rule.	200 to 220	280 to 350	...	50 to 75	300	400
2. On some small sections.	100 to 110	180 to 200	...	30 to 40	150	200 to 300
b) *Ordinary passenger trains :*						
Everywhere, except on one branch.	120 to 180	240 to 350	...	35 to 65	200 (250 in one case.)	350
c) *Goods trains :*						
1. Heaviest weight (few)	350 to 380	500	...	60	450	700
2. The others, except on one branch	270 to 350	330 to 370	...	40 to 95	450	500
C. — Other standard gauge lines.						
a) Express trains.	...	...	...	...	120 to 175	250
b) Passenger trains generally.	...	...	...	...	100 to 175	150 to 250
c) In some special cases.	...	...	...	...	25 to 80	40 to 100
d) Goods trains generally	...	...	...	...	100 to 150	150 to 250
D. — Narrow-gauge steam railways, trains of all kinds.						
1. Rhetian Railway	...	...	...	...	120	150 to 300
2. The others	...	...	...	...	40 to 80	80 to 150

The figures between brackets apply to exceptional cases.)

In order however to allow for increase in the goods traffic, the optional goods trains run in October 1903 were added; the statistics of the Federal Railway were utilized for this purpose, and special information was given by the St. Gothard Railway. In the case of the latter railway, there were more trains running south than north, so each direction was considered separately.

Similar determinations were also made for a day in winter, based on the winter 1903-1904 time-table; in the case of the Federal Railway, these were based on the actual amount of traffic hauled during January 1904; in that of the St. Gothard Railway, and of the other lines, the summer figure was reduced by an amount which was determined once for all.

It was only after all these factors had been determined, that it was possible to proceed to the calculation of the amount of power required. This term, amount of power required, is used rather loosely, and may express two different things, both of which require consideration here, namely :

a) The actual energy consumed during a given time (the total work);

b) The power required at any given moment, the output necessary (the activity, the load).

Knowledge of the first item is required in order to determine the total amount of water required every year, or the mean amount, and the mean output of the power stations. As for the second, the maximum must be known as on it depends the magnitude of all the installations for generating and distributing the current (from the pipes supplying the water to the conducting wires supplying the current), and also to determine what storage (whether hydraulic or electric) may be required.

Calculation of the quantity of energy required.

As regards traction, the quantity of energy required for overcoming the resistance due to gradients and the rolling resistance, per gross ton conveyed, for an outward and home journey on a given section, was calculated as follows : if the energy required for making an ascent were wholly recovered on the return journey during the descent, the energy required for overcoming the resistance of the gradients and the rolling resistance, for an outward and home journey over a section having a length of l metres, the whole rolling resistance being ρ kilograms per ton, would equal $2l\rho$.

But in the first place, in practice, if the down gradient per mil, is greater than the rolling resistance in kilograms per ton, the excess is absorbed by the brakes and is lost, and has to be replaced during the ascent. If we put l_1 for the length of the sections to which these remarks apply, and h_1 for the sum of the differences of height of the gradients of these lines, both in metres, this energy lost will be $1{,}000h_1 - \rho l_1$ kilogram-metres. Consequently in order to surmount these gradients and overcome the rolling resistance on an outward and home journey, the total quantity of energy required will be

$$A_{\rho+h} = 2\rho l + 1{,}000h_1 - \rho l_1, \text{ kilogram-metres.}$$

The values of l, l_1 and h_1 having been determined from the profile of the line, this equation was used to determine the quantity of energy required per ton conveyed. When it was necessary, in the case of certain trains, to consider the outward and the home journeys separately, a similar equation was used. The kinetic energy obtained by running downhill, which is at present absorbed by the brakes, but which may possibly be eventually recovered by means of suitable devices, and which is consequently of special interest in the case of electric traction, amounts to :

$$A_r = 1,000h_1 - \rho l_1,$$

also in kilogram-metres; this was determined separately in each case.

As regards the energy required for acceleration, which also has to be considered, we refer to what we have previously stated.

On the other hand, the shunting operations at stations also require a certain quantity of energy, which had to be calculated specially for each of the stations where there are shunting locomotives. (The quantity of energy required for shunting operations at the stations where are no special shunting locomotives is so small that it may be considered to be included in the amount added in rounding off the figures). The number of shunting locomotives in use at such stations was known, as well as the approximate time they were used every day.

It was assumed, on the basis of certain observations, that each shunting locomotive ran on the average 6 kilometres (3·7 miles) during each hour of service, and that the coal consumed per kilometre was 10 kilograms (35·5 lb. per mile) ; this gave the total amount of coal consumed by these locomotives. Then, assuming that 2 kilograms of coal were consumed for every useful horse-power-hour (4·47 lb. per British horse-power-hour) obtained, it was possible to calculate the work done, *i. e.* the total number of horse-power-hours supplied. As this is only a small fraction of the total quantity of energy required, this approximation is sufficiently accurate.

There remains the determination of the amount of energy required for *heating and lighting the trains;* with the present steam traction, only part of the energy is supplied by the locomotive, but in the case of electric traction, it is probable that the whole would have to be supplied by the current. It is also not an important fraction of the total quantity of energy required per year. It was calculated from the number of seats provided. The latter in its turn was calculated with sufficient accuracy from the number and weight of the component parts of the trains. The general statistics show that the tare of a carriage is about 0·25 ton (0·246 English ton) per seat provided; on the other hand observation shows that this applies to about half the weight of the trains. Consequently it was assumed that each ton of train corresponded to two seats. It is hardly necessary to remark that we are here considering the train weights in winter.

As regards *heating* it was assumed, from the results obtained with electric heating on the Freiburg-Murten line, that the consumption was 0·156 kilowatt per seat. (Carriages with forty-eight seats are very efficiently heated there with 7·5 kilowatts.) Assuming that the heating apparatus were used during half the running time, or during seven hours per day, it was found that the quantity of energy required for the heating amounted, per day and per seat, to

$$\frac{0{\cdot}156 \times 7}{0{\cdot}736} = 1{\cdot}48$$

or, in round figures, to 1·5 horse-power-hours; this was taken as a basis in our calculations.

As regards *lighting*, the amount assumed per seat was 2 glow-lamp candle-power (this figure has hardly as yet been attained), or 7 watts (at the lamps). Assuming, on the other hand, an average efficiency of 0·3 (that is approximately the figure of the system now applied on the Swiss Federal Railway), the power to be supplied to the train amounts, per seat, to

$$\frac{0{\cdot}007}{0{\cdot}3 \times 0{\cdot}736} = 0{\cdot}031 \text{ horse-power;}$$

and if this is required eight hours per day, the quantity of energy required per winter's day and per seat, will be

$$0{\cdot}031 \times 8 = 0.25 \text{ horse-power-hour approximately.}$$

In the original report of Mr. Thormann, the results of these calculations of the quantity of energy required are given in the form of a set of tables, containing the following information : length of section, mean weight and number of trains of each kind, tonnage hauled, the quantity of energy required (and when the case arises, recoverable) per ton and per journey, the number of seats, the total work of traction per ton-kilometre. These particulars are given for the different sections of each line with varying working conditions and profile ; thus for instance the Berne-Geneva is subdivided as follows : Berne-Freiburg, Freiburg-Romont, Romont-Palézieux, Palézieux-Lausanne, Lausanne-Morges, Morges-Geneva.

These tables also contain a number of other particulars ; we give the chief figures in table II.

Taking the whole of the Swiss steam railway system into consideration, the quantity of energy consumed during a summer day, measured at the tread of the driving wheels, may then be estimated to amount, in round figures, to

Traction, as per timetable, about	1,150,000 horse-power-hours.
Shunting operations, about.	50,000 —
Total . .	1,200,000 horse-power-hours.

Of this, the Swiss Federal Railway and the lines it operates absorb at least two thirds ; the Federal and Gothard Railways together at least 90 per cent. At this time of year, the consumption for heating is nil, and for lighting is negligible.

These results show that if the system adopted is one in which no energy is recovered on down grades, the quantity of energy required, measured at the tread of the wheels, is 1,200,000 horse-power-hours every day.

The total quantity of energy which the generating stations must supply every day then depends on the system selected and on its efficiency. It is at present impossible to come to a definite conclusion on this point. It may, however, be assumed that even when conditions are most unfavourable from this point of view, it will no doubt be possible to obtain a total mean efficiency, that is to say, a ratio between the useful work as measured at the tread of the wheels and the output of the turbines at the generating stations, of 0·45. Let us, however, for the moment assume that it is only 40 per cent. This is a sufficiently low figure, whether for traction by alternating current with three transformations (increase

Table II.

Particulars of work of hauling the trains on the Swiss steam lines during a summer day.

RAILWAY SYSTEM.	Number of train-kilometres (train-miles).	Ton-kilometres (English ton-miles).	Energy, in horse-power-hours (in English horse-power-hours) measured at the tread of the driving wheels.				
			Gradients and rolling resistance.	Energy set free.	Starting.	Total.	Per ton-kilometre (per English ton-mile).
Federal Railway, division I.	20,978 (13,035)	6,023,400 (3,683,720)	160,265 (158,075)	(28,260) [27,874]	59,725 (58,909)	219,990 (216,984)	0·0365 (0·0589)
— — — II.	21,252 (13,206)	6,337,300 (3,875,691)	181,980 (179,493)	(47,374) [46,727]	57,170 (56,389)	239,150 (235,882)	0·0376 (0·0606)
— — — III.	27,121 (16,853)	7,627,600 (4,664,798)	190,570 (187,966)	(21,500) [21,206]	87,615 (86,418)	278,185 (274,384)	0·0377 (0·0608)
— — — IV.	12,190 (7,575)	3,355,500 (2,052,117)	85,870 (84,697)	(10,985) [10,835]	38,920 (38,388)	124,790 (123,085)	0·0372 (0·0600)
Total for all the Federal Railways and lines operated by them	81,541 (50,669)	23,343,800 (14,276,326)	618,685 (610,231)	(108,119) [106,642]	243,430 (240,104)	862,115 (850,335)	0·0370 (0·0597)
St. Gothard Railway	12,830 (7,972)	4,550,400 (2,782,880)	158,180 (156,019)	(57,044) [56,265]	17,475 (17,236)	175,680 (173,280)	0·0386 (0·0623)
Other standard gauge lines	11,755 (7,304)	1,392,490 (851,603)	50,505 (49,815)	(19,613) [19,345]	15,230 (15,022)	65,735 (64,837)	0·0472 (0·0761)
Narrow-gauge steam railways	7,635 (4,744)	749,880 (458,603)	45,325 (44,706)	(16,826) [16,599]	4,040 (3,985)	49,365 (48,691)	0·0658 (0·1061)
Total for all steam railways.	113,761 (70,689)	30,036,570 (18,369,412)	872,695 (860,771)	(201,602) [198,848]	280,175 (276,347)	1,152,895 (1,137,143)	0·0384 (0·0619)
In the case of the narrow-gauge steam railways, the figures are divided as follows :							
Rhetian Railway.	3,174 (1,972)	367,100 (224,507)	20,915 (19,919)	(6,601) [6,511]	2,250 (2,219)	22,450 (22,143)	0·061 (0·0984)
Brünig Railway	1,185 (736)	151,900 (92,987)	10,895 (10,746)	(4,340) [4,281]	1,035 (1,021)	11,930 (11,767)	0·078 (0·1258)
Other lines.	3,276 (2,036)	230,880 (141,199)	14,235 (14,041)	(5,885) [5,805]	755 (745)	14,985 (14,780)	0·065 (0·1048)

It is convenient to add to the above figures the quantity of energy used in shunting, per day.

Swiss Federal Railways	...	...	...	...	...	41,800 (41,229)	...
St. Gothard Railway	...	...	...	...	...	2,340 (2,308)	...
Other standard gauge lines	...	...	...	...	...	750 (740)	...
Narrow-gauge lines (Rhetian Railway)	...	...	...	...	...	300 (296)	...
Total	...	...	...	...	...	45,190 (44,573)	...

Note. — The lines in course of construction in the spring of 1905, the mountain railways and the railways which are already electrified are not included in the above table, except the secondary standard-gauge electric lines of Burgdorf-Thun and Freiburg-Murten-Ins.

of pressure in generating station, reduction on conducting line and further reduction on car), or by conversion of three-phase current into continuous current, with use of accumulators. The turbines will, therefore, have to supply 3 million horse-power-hours per day.

Leaving out of consideration for the moment the possibility of the storage of water for long periods, but assuming storage sufficient to equalize the output during a day to be available, and considering for the moment only the summer consumption, which is the heaviest, these 3 million horse-power-hours if generated at a perfectly uniform rate during the day, would require a continuous output of 125,000 horse-power.

Waterpower equal to an even greater output than this is no doubt still available in Switzerland. One of the larger schemes lately launched, where considerable provision is made for the storage of water, would by itself be able to supply one fifth of the output required for the whole of Switzerland. But it must not be forgotten that the places where there is waterpower, where energy can be obtained, are unfortunately not distributed in our country as required, and moreover, as will be shown later on, not all the water-powers, not even all the " large " water-powers, are suitable for railway purposes; moreover, those which are near the frontier are hardly suitable for such purposes.

It is, therefore, advisable to see if it is possible to do with a smaller quantity of energy. In the first place, we will consider the question of recovering power on the down grades.

As regards the magnitude of the possible saving, it may be observed that out of a total consumption of 1,200,000 horse-power-hours during one summer day, the maximum which could possibly be recovered, with a theoretically perfect arrangement, would be about 200,000 horse-power-hours, namely about one sixth of the total. That would after all be quite an appreciable fraction. But its importance varies on different lines. For instance on the Brünig line, on the Rhetia line and on the St. Gothard, the energy which can theoretically be recovered represents about one third of the total energy, whereas the fraction on the Federal Railways generally is less than one eighth, and on section III only about one thirteenth. Now if we remember that any attempt at recovery involves complications of various kinds, and that recovery can never be quite perfect and complete, it appears clear that the question of any such recovery is either only of secondary importance, or only of importance on certain lines, and that the gain to be obtained from such recovery will always be comparatively small.

One important point is the *smaller quantity of energy required in winter*. The quantity of energy required during a winter day has been determined by the same methods (described above) as applied in the case of a summer day. Less energy is required in winter for traction; but more is required for heating and lighting. Particulars are given in table III.

Thus traction during a winter day requires on the average only three fourths of the quantity it requires during a summer day. On some lines, the proportion is only one half, and in one case, on the Brünig line, only one fourth; on the other hand, there are also cases where winter traction amounts to 90 per cent of summer traction.

Adding the consumption for heating and lighting, which on the average equals a little more than 13 per cent of that for traction, we find that the total winter consumption is on the average equal to 77 per cent of that in summer. The " winter day " we are considering here is not a minimum, but the average winter week-day. (The minimum is on Sundays, when there are no goods trains.)

Table III.

Particulars of energy required for hauling, heating and lighting the trains during a winter day.

RAILWAY SYSTEM.	Ton-kilometres (English ton-miles).	Energy required for hauling the trains, measured at the driving wheels, in horse-power-hours (in English horse-power-hours).				Energy required for heating and lighting.	Energy required, grand total.
		Gradients and rolling resistance.	Energy set free.	Starting.	Total.		
Swiss Federal Railways	16,028,900 (9,802,770)	430,625 (424,741)	(67,930) [67,002]	160,055 (157,868)	590,680 (582,609)	81,755 (80,638)	672,435 (663,247)
Shunting operations	...	24,000 (23,672)	...	16,000 (15,781)	40,000 (39,453)	...	40,000 (39,453)
St. Gothard Railway.	3,050,000 (1,865,280)	107,100 (105,637)	(38,000) [37,481]	(11,900) (11,737)	119,000 (117,374)	11,200 (11,047)	130,200 (128,421)
Other standard gauge lines	926,700 (566,740)	33,290 (32,835)	(12,155) [11,989]	10,245 (10,105)	43,535 (42,940)	10,585 (10,440)	54,120 (53,380)
Total, standard gauge lines . . .	20,005,600 (12,234,790)	595,015 (586,885)	(118,085) [116,472]	198,200 (195,491)	793,215 (782,376)	103,540 (102,125)	896,755 (884,501)
Narrow gauge lines	393,130 (240,430)	21,910 (21,610)	(7,725) [7,619]	2,060 (2,032)	23,970 (23,642)	6,340 (6,253)	30,310 (29,895)
Grand total. . .	20,398,730 (12,475,220)	616,925 (608,495)	(125,810) [124,091]	200,260 (197,523)	817,185 (806,018)	109,880 (108,378)	927,065 (914,396)

Now let us assume that we are using water-powers having such storage capacity that the differences between summer and winter consumption can be equalized. It will hardly be possible to avoid the use of storage reservoirs of such size, owing to the necessity of providing for the variations in the supply, which will be considered later on; in many cases, it will also be absolutely necessary to provide for the differences between the rainfall at different seasons.

If the installations provide for such variations, we need only consider the annual mean of the mean daily consumption of energy for the year, or the total quantity of energy required per year.

This has been calculated as follows : as basis the annual ton-mileage was taken; this was determined by taking the average of a week-day in summer and one in winter, reduced by 7 per cent to allow for the fact that there is no goods service on Sunday (the goods service is assumed to be 50 per cent of the total service). To allow for the heating and ligthing, one third of that required on a winter day was added; this corresponds to complete heating during 120 days of the year. The results are shown in table IV.

The *mean work of traction* in ton-kilometres is 78 per cent of the summer traction on standard-gauge lines and 68 per cent of that on narrow-gauge lines.

Table IV.

Particulars of energy required for hauling, heating and lighting the trains during a mean day (mean of the year).

RAILWAY SYSTEM.	Ton-kilometres (English ton-miles).	Energy, in horse-power-hours (in English horse-power-hours) measured at the tread of the driving wheels.					
		For hauling.				For heating and lighting.	Grand total.
		Gradients and rolling resistance.	Energy set free.	Starting.	Total.		
Swiss Federal Railways	18,030,000 (11,026,580)	476,500 (469,990)	(82,400) [81,274]	189,500 (186,910)	666,000 (656,900)	27,300 (26,927)	693,300 (683,827)
Shunting operations	...	27,000 (26,631)	...	18,000 (17,754)	45,000 (44,385)	...	45,000 (44,385)
St. Gothard Railway	3,460,000 (2,116,020)	121,000 (119,347)	(43,200) [42,608]	13,500 (13,315)	134,500 (132,662)	3,700 (3,649)	138,200 (136,311)
Other standard gauge lines	1,061,400 (649,120)	38,155 (37,634)	(14,785) [14,583]	11,780 (11,619)	49,935 (49,253)	3,540 (3,491)	53,475 (52,744)
Total, standard gauge lines	22,551,400 (13,791,720)	662,655 (653,601)	(140,385) [138,467]	232,780 (229,600)	895,435 (883,200)	34,540 (34,067)	929,975 (917,267)
Narrow gauge lines	526,710 (322,120)	30,755 (30,335)	(11,030) [10,879]	2,860 (2,820)	33,615 (33,155)	2,175 (2,145)	35,790 (35,300)
Grand total	23,078,110 (14,113,840)	693,410 (683,936)	(151,415) [149,346]	235,640 (232,420)	929,050 (916,355)	36,715 (36,212)	965,765 (952,567)

The mean total daily work in horse-power-hours for the whole year thus equals about 80 per cent of the work on a summer day and 105 per cent of the work on a winter day. According to the statements made above, the 966,000 horse-power-hours (in round figures) of work, measured at the treads of the driving wheels, as shown in the table, would correspond to about 2,400,000 horse-power-hours given by the turbines of the power stations; the turbines must therefore develop 100,000 horse-power constantly.

It will be of interest to insert here a table which shows the relation of the energy required for traction work proper to that required for heating and lighting and to that which theoretically can be recovered (*see* table V).

Output required. Maximum load.

The output required for the different sections and the different lines was determined not only with a view to the planning of the waterpower stations, but also to enable the conducting and distributing systems to be designed. Here, however, we will only consider the particulars and results obtained from the former point of view. The procedure was as follows.

Table V.

Energy, in percentages of that required for traction proper (gradients, rolling resistance, starting).

—	For heating and lighting.	Theoretically recoverable.		
		Vis viva.	Braking on down grades.	Total.
Very busy weekday in summer.				
Standard gauge lines	...	25·7	16·0	41·7
Narrow gauge lines	...	8·2	33·6	41·8
Mean, all lines.	...	24·8	16·7	41·5
Weekday in winter.				
Standard gauge lines	13	25·0	14·9	39·9
Narrow gauge lines	26·5	8·6	32·3	40·9
Mean, all lines.	13·3	24·4	15·3	39·7
Mean day of year.				
Standard gauge lines	3·9	25·9	15·7	41·6
Narrow gauge lines	6·4	8·5	32·7	41·2
Mean, all lines.	4·0	25·3	16·3	41·6

In the first place, a table of speeds on gradients was drawn up, corresponding approximately to the speeds attained by the existing steam trains under the most favourable conditions. The scales drawn as smoothed curves give approximately the values shown in table VI.

On the basis of these speeds and of the assumptions made above as to the rolling resistance, *power curves were drawn for a 100 ton train*, showing the power required as a function of the gradient; this was done separately for each kind of train. In this way, it became possible to construct, for each section and each kind of train, the diagram of a 100 ton train, with the times as abscissæ. In other words, the horse-power required could be plotted directly above the train curve as ordinate, and that for each section, on the assumption that over that whole section the train was going up the steepest gradient shown on the profile of that section. It is clear that this simplified method of computation can be adopted in determining the maximum output required, as it gives the actual maximums; but if used for determining the mean output, or the mean work (by measuring the areas by planimeter), the method would give much too high figures.

If such diagrams are made for all the trains running, according to the time-table, in a day, a *diagram of the 100 ton trains of a section* can then be obtained from them.

Table VI.

—	Speed, in kilometres (in miles) per hour, on a gradient of				
	0 per mil.	5 per mil.	10 per mil.	25 per mil.	35 per mil.
Standard gauge lines generally.					
Express trains	80 (49·7)	67 (41·6)	56 (34·8)	40 (24·9)	...
Ordinary passenger trains	70 (43·5)	56 (34·8)	45 (28·0)	30 (18·6)	...
Goods trains	50 (31·0)	40 (24·9)	31 (19·3)	20 (12·4)	...
St. Gothard Railway.					
Express trains	75 (46·6)	60 (37·3)	51 (31·7)	40 (24·9)	...
Ordinary passenger trains	55 (34·2)	46 (28·6)	40 (24·9)	30 (18·6)	...
Goods trains	40 (24·9)	34 (21·1)	29 (18·0)	20 (12·4)	...
Narrow gauge lines.					
All trains	40 (24·9)	36 (22·4)	31 (19·3)	20 (12·4)	18 (11·2)

In this case also, the time-table of summer 1904 was taken as basis, and it was assumed that all the trains, whether regular or optional, were running.

Finally, in the case of the Federal lines, the maximum weights (extracted, as stated above, from the statistics issued by the management) of the passenger trains in August 1904 and of the goods trains in October, were then applied for each train separately, and from these the *load diagram of the line* obtained, by adding together the requirements of all the trains at intervals of ten minutes (or at shorter intervals, if required). In the case of the other lines, the maximum weight of the train, as given in the time-table, was taken as basis.

It was moreover assumed, that any two successive trains were at least one block apart. On down gradients of 6 per mil or less, it was assumed that as much was required as on the flat; on steeper gradients it was assumed that the train would run by itself. No special allowance was made for acceleration. As the accelerations now usual are about 10 to 15 centimetres (4 to 6 inches) per second per second, the omission is fully counterbalanced by the assumption that every train from the very start goes up the steepest gradient of the section. It is probable that the whole of these assumptions result in a rather higher load than would actually occur.

By means of the power diagrams of the different lines, it was then possible to make the *diagrams of a given railway system*, by simply adding the ordinates referring to the same time. The greater the extent of the system dealt with in this way, the more regular the shape of the curve representing the total output required. With a view to the ultimate utilization of these diagrams for determining the energy-distributing centres and the equipment of the power stations, such diagrams were made for each small section separately. Then, according to the position of the water-power available, several such sections were grouped together and assigned to one given distributing centre, and several such centres supplied by one given power station.

The whole of the Swiss steam railway system was in this way divided into about 140 suitable sections and the load diagrams of each of these sections determined.

As explained above, the daily work and consequently the mean load per twenty-four hours had also been determined for the same sections.

The ratio between the maximum load and this mean load varies on most sections between 7 and 12; but on a considerable number of sections, the ratio attains values like 15 and 20, and, as a maximum, 37. On the other hand in a certain number of cases it falls to about 6, and in some exceptional cases (notably on the St. Gothard) to 4 and 3·2; these are relatively long mountain sections.

These figures show that the *variations in the load* are exceptionally great. If now we consider a certain number of sections, supplied from one future centre, as forming one small group, we find that the differences are not very much smaller. As an instance, we will take the Etzwylen group : The service extends over twenty-two hours of the day, and the diagram shows that the mean output (calculated for twenty-four hours) required is 1,517 horse-power (1,496 British horse-power). In the twenty-two hours, there are about 25 maximums and minimums. The maximum is in this case 10,500 horse-power, *i. e.*, 6·9 times the mean. (The greatest variation in the daily consumption is equal to about 60 per cent of the maximum power.) On the other hand, the separate sections which together constitue these groups show maximums of about 10 times their respective means, and by adding up the maximums of the different sections we obtain 14,050 horse-power. Owing to the absence of coincidence in the maximums of the separate sections, their grouping makes it possible to bring down the maximum power requisite from 14,050 to 10,500 horse-power; this is an improvement, in the ratio of maximum to mean, from about 10 to 6·9. The group in question is composed of five sections, and the total length of line in operation is 161·34 kilometres (100·25 miles).

Let us now apply the same method to a larger combination, by adding to the Etzwylen group the Wil group, 187·9 kilometres (116·8 miles), and the Rorschach group, 89·3 kilometres (55·5 miles). This gives us a total length of 439 kilometres (273 miles) of line; it corresponds approximately to Division IV of the Federal Railway, without the Altstätten-Chur line, but with the secondary lines included. In this case, we get a maximum which is only 5 times the mean (for twenty-four hours), and the greatest variation in the load (difference between the maximum and the minimum, excluding the start from zero and stops) is only about 35 per cent of maximum. Analogous conditions are to be observed in groups of similar importance, *i. e.* such as require a maximum of say about 30,000 horse-power, measured at the treads of the driving wheels. There will be but few cases of appreciably larger groups, fed from a single power station. Examination of the separate cases has shown that even then the ratio of maximum power to mean power can scarcely be appreciably reduced to below 5; this figure therefore probably represents the limit of reduction of this coefficient.

Organization of the power stations.

The information contained in Mr. Thormann's report will serve as basis in planning the organization to be adopted in obtaining and distributing the energy. Several important results are at once evident. We will consider some of them here.

In the first place, the generating stations must be able to stand enormous fluctuations in their load. Even if as many sections are grouped together as possible, so as to utilize the largest waterpowers available, it is necessary that the equipment and all the installations concerned in this maximum output, must be able, during short periods of time, to give an output equal to about five times the mean output. In the case of smaller groups, and this case will naturally arise in the case of smaller generating stations and especially in that of transformer substations, the equipment of the stations may in many cases have to provide for ten times the mean output, or even more.

It is also clear that under the existing conditions (and probably always) it will be impossible to provide fully for the fluctuations in the load by the use of accumulator batteries alone.

Now if these fluctuations are to be provided for solely by the power stations or by water storage, then the hydro-electric installations must be large enough to satisfy the coefficient mentioned above. Therefore, only those water-powers can come into consideration, in which it is possible to effect such storage by means of lakes; installations in which the excess water runs to waste at times when the load is not a maximum, will certainly be very uneconomical for railway purposes. They, therefore, can only come into consideration if combined with other installations in which storage is possible. As reasonably cheap storage is only possible in the case of high falls, it is advisable to consider more especially the utilization of such falls.

When water storage cannot conveniently be provided for directly, it will be necessary to try to obtain it indirectly at other points, by means of electric motors, pumps and high-level reservoirs.

Let us in conclusion attempt to obtain at least an approximate notion of the total mechanical power of all the hydraulic installations. With this object in view we may, as a first approximation, assume that the efficiency of the transmission will be the same when the ouput is a maximum as when it is the mean, namely that it will be as assumed above in the determination of the energy. The efficiency of the motors, transformers, etc., is greater when the load is a maximum; but that of the conducting system is smaller, by nearly the same extent. In this case also, we may assume that under the most unfavourable conditions there will be an efficiency of at least 45 per cent as between the turbines and the rails; all the more so as we may assume that this figure will not be appreciably affected by the use of accumulator batteries. In the interests of uniformity however, we will in this case also only count on an efficiency of 40 per cent, adopting 5 as the ratio of maximum load to mean load. Then the mean, 100,000 horse-power, would correspond to a total of 100,000 × 5 = 500,000 horse-power, to be developed by the turbines of the power stations. These 500,000 horse-power would therefore only be utilized, on the average, as if the maximum power was developed during $\frac{24}{5}$ = about 4 $^3/_4$ hours per day.

If only very large central power stations were to be used, it is probable that these 500,000 horse-power would suffice. But if it is necessary to have a considerable number of smaller stations, it is possible that more horse-power would be required, as the ratio in question is larger in the case of small systems.

If energy can be recovered on the down grades, the utilization of the maximum would be still further reduced, although the absolute maximum itself would probably not be affected. The daily or annual total quantity of energy required would however be reduced.

The great fluctuations in the load are unfavourable to the organization of the waterpowers and of the mechanical installations of the power stations. They limit the number of waterpowers suitable for the purpose, and careful selection will be necessary; the consequent capital expenditure will also be greater. Although it appears, taking as basis the total annual quantity of energy required, that this can certainly be obtained from waterpowers which are still available, yet the results arrived at show us that the waterpowers which are suitable for railway purposes want careful looking after and steps should be taken in time to reserve them for the purpose.

[621 .138.2]

THE COALYARD AT COLOGNE STATION (EIFELTOR),

By C. GUILLERY,

ROYAL COUNCILLOR FOR CONSTRUCTION.

Figs. 1 to 11, pp. 805 to 809.

(*Zeitschrift des Vereines deutscher Ingenieure.*)

Among the various installations which have been designed in the last few years for the supply of coal to locomotives, that erected at the Cologne station (Eifeltor) is worthy of special note. This plant was constructed and erected by the firm of Carl Schenck of Darmstadt to their own designs; it comprises a travelling gantry running on rails and fitted with a traversing carriage with grab gear (figs. 1 to 4), together with coal hoppers and cinder bins placed on each side of the coal store. The plant has now been at work for a considerable time and has given excellent results; it has only required the few improvements which experience in working usually demands. The cost of installing the constructional steel work and the mechanical details supplied by the contractors is not higher than in the case of an installation of the same magnitude on the well known Hunt system. Moreover, it does not require the expensive underground storage room of the Hunt system which can only be arranged when a considerable depth can be reached without finding water. Although this latter condition is met by the high level of the Cologne station (Eifeltor), the travelling gantry and grab were preferred owing to the good results obtained by the Baden State Railways at Mannheim with a similar plant.

It has been frequently asserted that the use of a grab crane for loading tenders is dangerous, but the skill of the crane driver is an important factor. The risks are moreover no greater than those which attend the use of a powerful travelling crane in an engineering works, where no objection is ever raised to its use. Coal wagons of such narrow width that the grab cannot clear inside the body are becoming more and more rare and will soon disappear. The Hunt system is moreover not free from certain disadvantages. An accident may occur in the pit in which the conveyor works, and the breakage of the large lumps of coal which is often necessary is a troublesome operation. The work of the employees in doing this and charging the conveyors is somewhat dangerous, in winter particularly, in case of hard frost and when the ground is covered with ice. The Schenck gantry is of neat design and does not obstruct the signalman's view of the

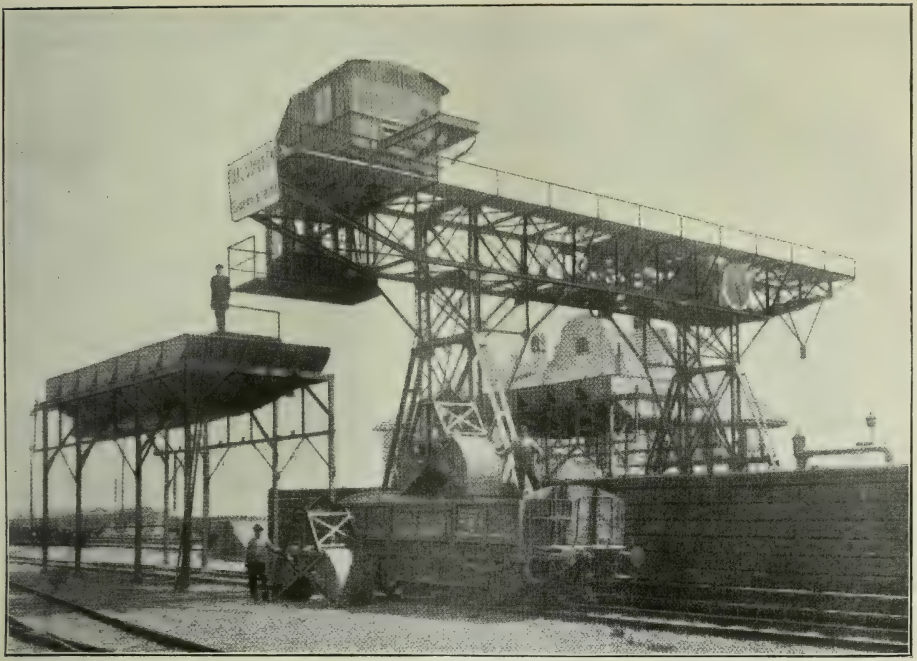


Fig. 1.

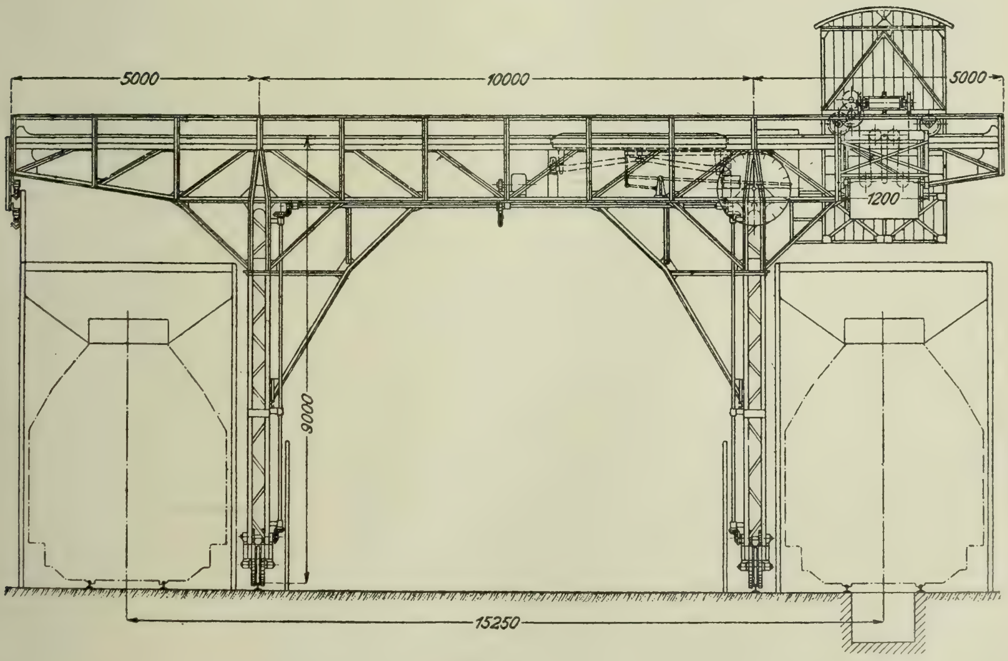


Fig. 2.

Figs. 2-11. — Dimensions are given in millimetres.

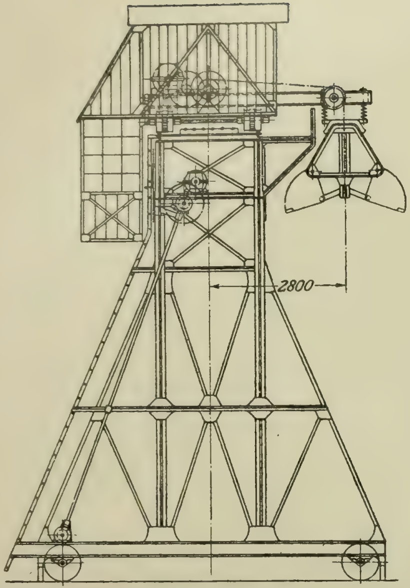


Fig. 3.

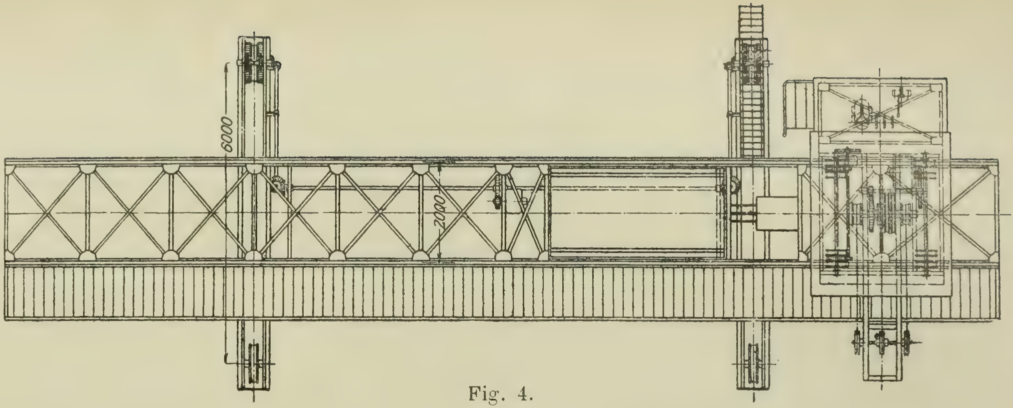


Fig. 4.

Fig. 5.

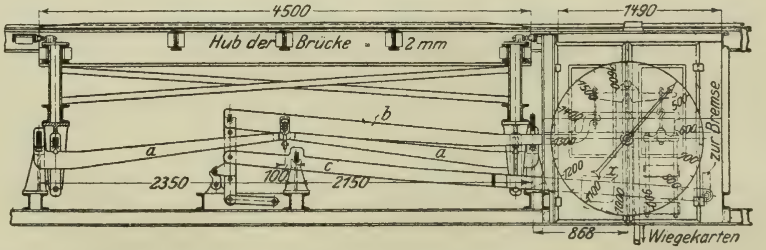
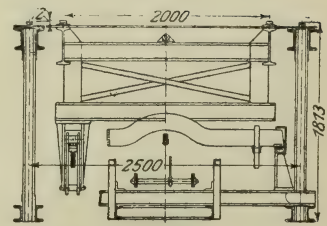


Fig. 6.



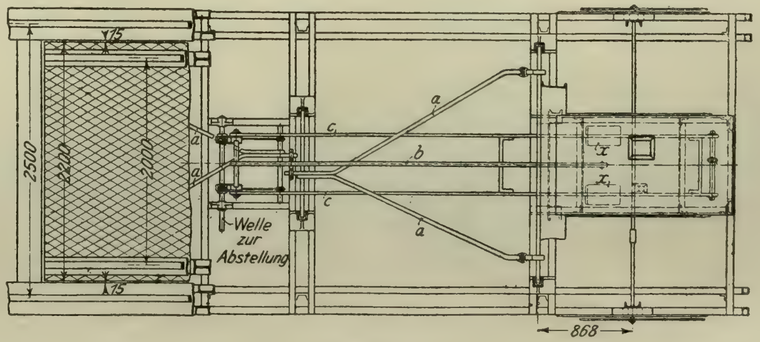


Fig. 7.

Figs. 5 to 7.

Explanation of German terms : Hub der Brucke = Vertical travel of weighbridge. — Welle zur Abstellung = Shaft for disengaging. — Wiegekarten = Weight card. — Zur Bremze = To brake.

station. These reasons would not prove decisive if the Schenck gantry had any appreciable disadvantages, but on the contrary, it presents several incidental advantages. We do not here propose to discuss the utility and applicability of the Hunt system, of the working of which a lengthy experience is available. It will remain to be seen how far the excess of first cost of the Hunt system will be repaid, according to the amount of traffic, by reduction in expense of working. In any case, it will not be possible to arrive at the true working expenses of the Schenck gantry until the Cologne Station (Eifeltor) is in full working condition, that is, after the junction line which will cross the Rhine south of Cologne between the stations of Cologne (Eifeltor) and Kalk-Nord, the construction of which is now well advanced, has been completed. When this takes place a large number of locomotives, probably 60 to 80, will have their shed at Cologne (Eifeltor). In this article we shall only deal with those features which appear to us to be necessary towards understanding the drawings.

The motor working the travelling gantry is supplied with continuous low tension current, from the railway generating station situated close to the railway station. It is supplied through special cables separate from those for lighting and power. All the pieces of mechanical apparatus at the station, including the points, are electrically operated.

Each of the three movements of the grab: lifting the charge, cross traverse of the carriage on the gantry and movement of the gantry along the rails is effected by a separate motor. The motor which operates the lifting gear is of 25 horse-power and lifts the full grab at a speed of 60 centimetres (1 ft. 11 $^5/_8$ in.) per second. The full charge of the grab is about one ton of coal. The motor of the carriage develops 6 horse-power for a speed of traverse of 1·5 metres (4 ft. 11 in.) per second and the motor which travels the whole gantry develops 12 horse-power for a speed of 1 metre (3 ft. 3 $^3/_8$ in.) per second.

The winch has one shaft on which are three drums; two operate the lifting rope and the third, which is placed between the other two, operates the discharging rope. The ropes are of steel wire of very great flexibility. The strength is calculated for a factor of safety of 10. The discharging drum runs free on the shaft with which it can be engaged by means of a friction clutch. The lifting drums and also the discharging drum are fitted with disc brakes which act on each of the drums independently. The lifting drums are keyed to the shaft.

An automatic weighbridge without springs (figs. 5 to 7) is arranged between the rails of the traverser and is fitted with rails which are independent of those carrying the traverser. The rails of the weighbridge are at a higher lever than the traverser rails and are champered at the ends; the carriage has double wheels which permit it to be lifted from the outer rails when run on to the weighbridge. When this takes place, the load on the carriage is transferred by the levers a, a and b to the levers c, the movement of which operates the automatic weighing gear. The latter consists of a lever arm, one end of which is attached to the lever b while the other end carries a pan. Under the action of the levers c, a jockey weight moves on this arm till equilibrium is obtained; at the same time an index hand rotates and shows the net weight on a dial. After the carriage has travelled away, the weighbridge is returned by the counterweight x to its normal position. A disengaging gear is fitted which allows the carriage to be run over the bridge without operating the weighing gear.

By means of this weighing gear, the operator knows exactly how much coal has been charged into each of the hoppers placed above the track on each side of the coal store.

The coal brought in wagons can be lifted either into the hoppers; or, if these are full, on the heap or directly on to the tender of a locomotive if required. Coal is taken from the heap as required for filling the hoppers. The grab can traverse the whole length of the coal heap.

The method of operating the grab is as follows : after the brake has been taken off, the grab is dropped into the wagon to be unloaded or is dropped on to the heap. Then the winch motor is set to work to lift and causes the grab to close. The discharging drum is then thrown into gear : the ropes of the lifting drums and of the discharging drum are all coiled equally and the grab rises. On reaching the top of its travel the lifting brake is put on by an electric-magnet. Then the carriage with the grab is traversed in the desired direction by inclining the lifting control lever to one side or the other in the same direction. Each lever moves in the direction in which movement is to take place. On arriving at the position desired, that is over the hopper, the heap or the tender, the grab is opened and emptied by keeping the discharge brake on and releasing the lifting brake.

The grab when at the top of its lift, comes in contact with a stirrup piece, underneath and attached to the overhanging cantilever, which prevents overload of the lifting gear due to shock of the grab against the cantilever and at the same time prevents swinging during the travel of the carriage. The grab is of steel plate and the edges are reinforced with forged steel jaws. The grab is closed by means of an arrangement similar to that of a block and tackle. The grab can be lowered into the pit constructed between the tracks on which the locomotives run and consequently can also be used for the removal of cinders and clinkers cleared from the fireboxes of the locomotives.

The coal and cinders are emptied from the high level hoppers by opening shutters in the vertical sides after lowering the shoots (figs. 8 and 9.) Whenever possible the cinders are loaded direct from the pits into special wagons built and kept ready for this purpose. After a hopper has been emptied, the handle operating the door is disengaged enabling this to fall when it is secured by the engagement of a spring bolt. The greater part of the weight of the shoots is balanced by a counterweight which facilitates their manipulation and fastening. The coal hoppers being placed above and across tracks on which locomotives run, it has not been possible to arrange the shoots in one piece and of fixed length, because when lowered they would not reach low enough to prevent the formation of an excessive quantity of dust during loading operations. Consequently each shoot is fitted with a movable lengthening piece (figs. 10 and 11) which falls at the time the shoot is lowered and gives the necessary additional length. This lengthening piece returns when the shoot is lifted and has been found to give a perfect practical solution of the problem. If the neighbouring track were at a sufficient distance another method might be employed by turning the shoots through 90 degrees outwards so that they would cross the sixfoot way. They might then be placed at a lower level and the shoots, without the lengthening pieces, would fall sufficiently low to prevent the formation of an excessive quantity of dust. In this case it would be necessary to increase somewhat the length of traverse of the grab.

The sides of the hoppers are given a sufficient inclination to prevent coal clinging to them when being discharged.

The three motors drive with straight tooth gears. The motor which travels the whole

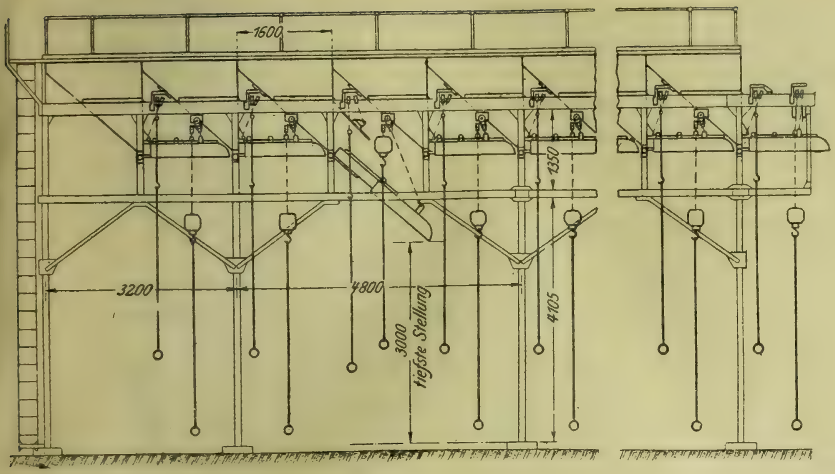


Fig. 8.

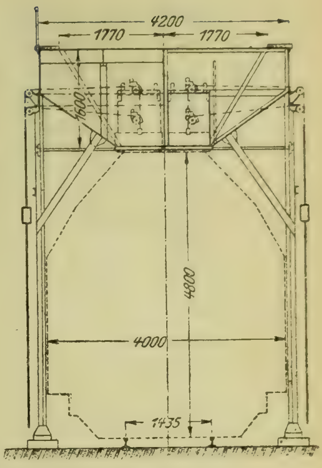


Fig. 9.

Explanation of German terms : Tiefste Stellung = Lowest position.

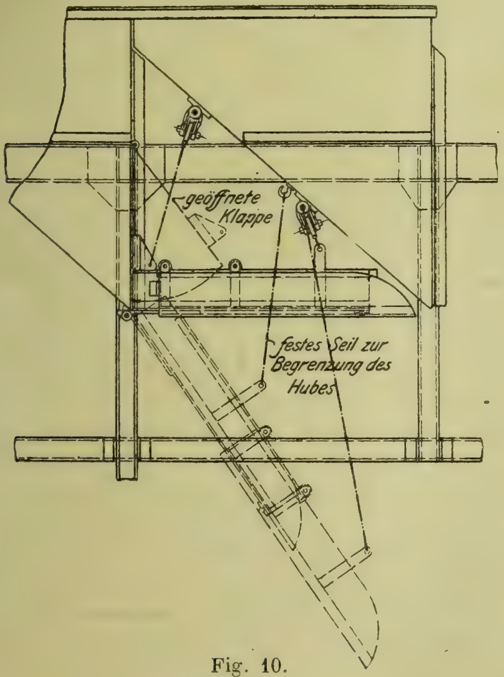


Fig. 10.

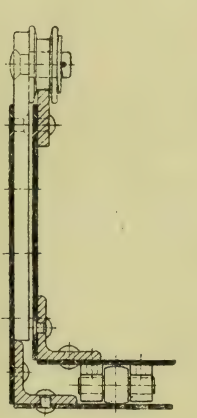


Fig. 11..

Explanation of German terms : Festes Seil zur Begrenzung des Hubes = Fixed rope to limit the fall of the shoot.
Geoffnete Klappe = Open swing-door.

gantry is placed in the centre of the bridge. The shaft which transmits the movement to both sides of the gantry runs in ball bearings and its parts are each fitted with Oldham couplings. One of the carrying wheels of the gantry operates a bell which rings when the gantry is travelling. The heaviest load carried on any one wheel, when the carriage with the grab is in the position giving maximum load, amounts to 11 tons. In case of fracture of a carrying-wheel or an axle pin, the crane bears on the rail by a portion of the frame which normally serves the purpose of rail guard. The traversing gear for the carriage has straight teeth and drives on to one axle.

The gantry is set in motion by means of a special starting gear.

As soon as the limit of travel is reached in each direction the current is automatically cut off, and movement can then only take place in the opposite direction. The starting gear consists of reversing controller switches similar to those in use on tramways.

The current for the gantry and the carriage is collected by means of trolley wheels from naked copper conductors. The main supply conductor is suspended at the ends from two independent posts; between these points it is carried by the coal hoppers. There are thirty-six coal hoppers in all.

Only under exceptional conditions is it necessary for anyone to enter the coal store; it is arranged with high sides and without doors so that it is easily inspected and it is difficult for coal to be improperly removed. The whole area of the store may be filled with coal up to the top of the sides. The latter are constructed of old sleepers and rails secured together by tie-rods at intervals.

[625 .11 (.494 + .45)

THE SPLÜGEN RAILWAY.

Figs. 1 to 3, pp. 812 to 815.

(*Schweizerische Bauzeitung.*)

On November 8, 1906, the canton of Graubunden, acting on behalf of a limited company about to be formed, applied to the Federal authorities for a concession to construct the Splügen railway, the plans for which were worked out by Dr. Ed. Locher-Freuler. We extract from this application the following information, which may be of interest to our readers, and add the plan and profile of the proposal line (figs. 1 and 2).

TECHNICAL REPORT.

" The present proposed concession is based, except as regards the tunnel, on the work carried out in 1890 and 1905-1906 by chief engineer Dr. R. Moser, whereas the plan and profile of the tunnel are based on the proposals of Professor Dr. Hennings.

" The Splügen standard-gauge line starts from Chur station, where it joins the lines of the Federal Railway, and goes along the left side of the Rhetia Railway to Ems, where the Splügen station will be alongside the Rhetia station. From Ems the Splügen line then diverges from the Rhetia Railway, passes through the Vogelsang by means of a tunnel, and crosses the Upper Rhine. It then goes along the left bank of the river, passing under the Rhetia Railway, to Rothenbrunnen station, which will be at about the same height as the Rhetia station. It is not advisable to run the line through Reichenau, and have a station there adjoining the Rhetia station, as very little room is available there and the line would be longer. The traffic to and from the Vorder-Rhein valley can pass through Chur, Ems, Rothenbrunnen or Thusis, so that this reason does not justify any increase in the length of the Splügen line. The sharpest curve between Chur and Rothenbrunnen has a radius of 400 metres (20 chains) and the steepest gradient is one of 10 per mil. This section is thus still an ordinary valley railway and the trains of the Federal Railway which arrive at Chur can, therefore, run on without alteration in their composition to Rothenbrunnen. At the latter point suitable and inexpensive land is available for a shunting station, for a custom house (if required) and for locomotive

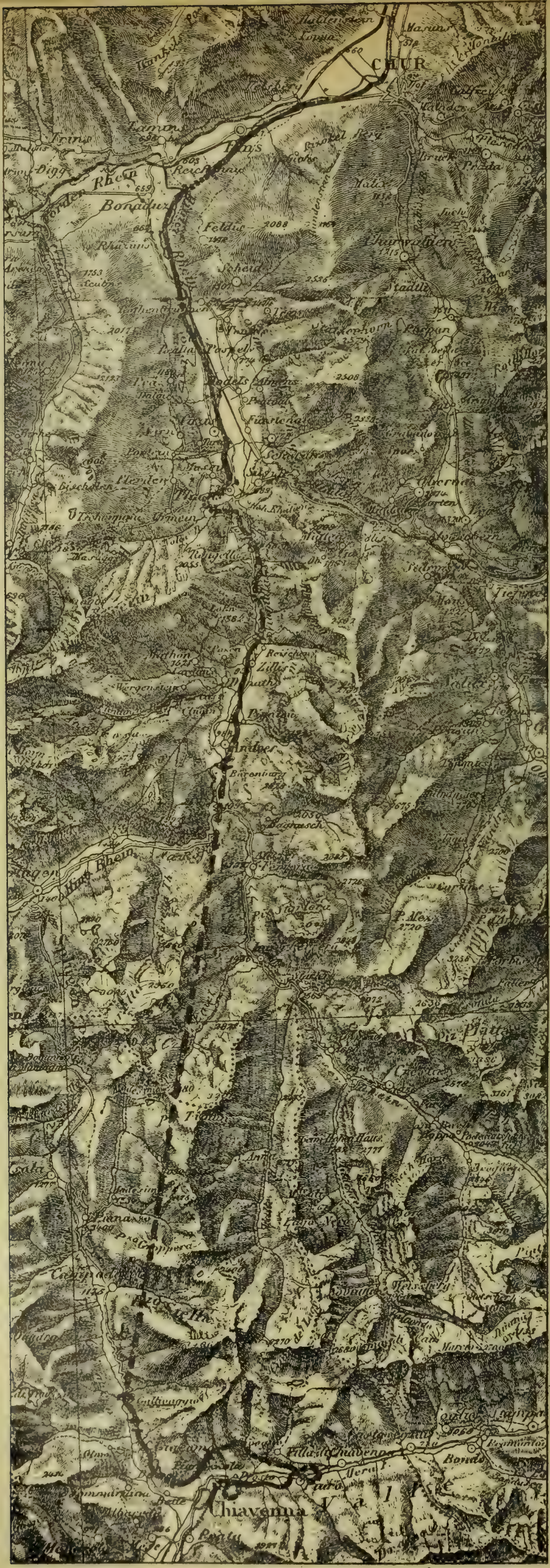


Fig. 1. — Splügen Railway. — Plan of Dr Locher-Freuler's project, 1906.

sheds, etc., whereas these would be a much more difficult and expensive matter at Chur. The Chur-Rothenbrunnen section will be operated with steam and the Rothenbrunnen-Chiavenna section with electric locomotives.

"The ascent to the north mouth of the Splügen tunnel begins at Rothenbrunnen; the steepest gradient is 26 per mil and the steepest curve has a radius of 300 metres (15 chains). A short section near Cazis station excepted, the line is always on the right side of the Rhetia Railway. The new Thusis station will be at a height of 718·03 metres (2,355 ft. 9 in.), whereas the Rhetia station is at one of 700·50 metres (2,298 ft. 3 in.), being 17·53 metres (57 ft. 6 in.) lower. If it were desired to have the new Thusis station at the same height as the Rhetia station, this would involve a considerable increase in the length of the helicoid tunnel which will have to be constructed above Thusis. The resulting advantages would be insignificant as compared with the increased expense. After passing under the Nolla river in a helicoid tunnel, the line goes along the bottom of the valley to the Rongellen-Zillis and Andeer stations.

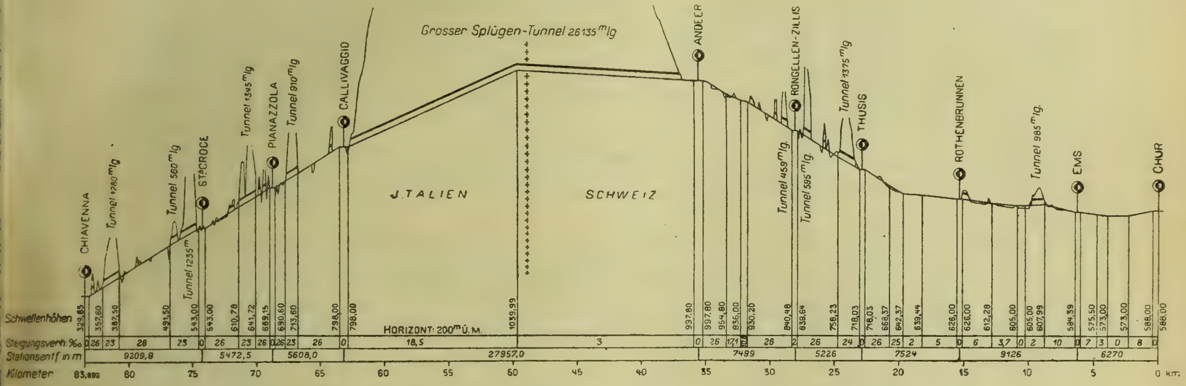


Fig. 2. — Splügen Railway. — Profile of Dr. Locher-Freuler's project, 1906.

Explanation of German terms: Grosser Splügen-Tunnel = Main Splügen tunnel. — Horizont. 200m ü. M. = Datum line, 200 metres (656 ft. 2 in.) above sea-level. — Italien = Italy. — Schweiz = Switzerland. — Schwellenhöhen = Height of top of sleepers. — Stationsentf. in M. = Distance between stations. — Steigungsverh. ‰ = Gradient per mil.

"The Splügen tunnel is 26,135 metres (16 miles 422 yards) long, and commences at kilometre 36·990 (mile 22·985); the entrance is 1,355 metres (4,445 ft. 7 in.) beyond Andeer, and is at a height of 1,000·78 metres (3,283 ft. 5 1/2 in.). The highest point of the tunnel, 1,040 metres (3,412 ft. 1 1/2 in.), at kilometre 50·575 (mile 31·426), is reached by a gradient of 3 per mil; the line then descends to the south (gradient, 18·5 per mil) to the national frontier, which is at kilometre 50·925 (mile 31·644); the south end of the tunnel is at kilometre 63·125 (mile 39·225) at a height of 800·75 metres (2,627 ft. 2 in.).

"The length of the tunnel thus is :

13,935 metres (8 miles 1,160 yards) in Swiss territory.
12,200 — (7 — 1,022 —) in Italian territory.

Total. . . 26,135 metres (16 miles 422 yards) as stated above.

"The south end is 1,000·78 — 800·75 = 200·03 metres (656 ft. 3 in.) lower than the north end.

"The centre line of the tunnel is in a vertical plane, except as regards a short section near the north end. The gradients of 3 and 18·5 per mil must be considered as maximums which may be reduced as the headings are advanced; the object being to reduce the time required for the construction of the tunnel as much as possible, by avoiding having headings with contrary gradients.

"If steam locomotives were used, a rise of 18·5 per mil would not be advisable, as excessive smoke would be produced. This difficulty disappears in the case of electric traction, and only questions of the adhesion in the tunnel prevent the use of as steep gradients as on the open line. At present there is not yet enough experience as to how conditions will be in a long tunnel through which electric trains run; it may, however, be taken as certain that an electric locomotive can haul a train up a gradient of 18·5 per mil in tunnel, if it can haul it up a gradient of 26 per mil in the open, at least if the air in that 18·5 per mil section (here the south section) is not saturated with moisture which it deposits on the rails. This will not be the case in the southern half of the tunnel, as owing to the great difference in height of the two ends (the north end being 200 metres [656 ft. 2 in.] higher than the south end), there will nearly always be a strong natural current of air from the south to the north, and it will seldom be necessary to produce such a current, always from the south to the north, artificially. The air entering the south end becomes warmed gradually; it is therefore dry and improves the adhesion. Similarly, in order to overcome the air resistance in the tunnel, a south to north current is better than the opposite.

"The tunnel will have a single track, with three passing places, each consisting of double track sections 500 metres (547 yards) long. The exact location of these passing places will only be fixed when the headings have shown that no excessive pressure exists there. In order to facilitate starting at the passing place in the south half of the tunnel, the gradient there will be reduced to 10 per mil. It is not necessary that the three passing places should divide the tunnel, that is the section between the two end stations, Andeer and Gallivaggio, into four exactly equal parts; it does not matter if any of the passing places is a hundred metres further north or south. It is at these points that trains will cross, or, the case arising, pass each other. The crossing of electric trains in a well-ventilated and well-lighted tunnel is certainly attended with less risk than on the open line at night, in times of fog or snow. In order that passengers, if trains are late, may not have to be kept waiting in the tunnel, the station masters of Andeer and Gallivaggio can arrange the times of the trains so that they reach the passing place at the same time. It is probable that for a long time after the tunnel is opened, the middle passing place will suffice. The two others will come into use as soon as the traffic makes this necessary. Owing to the improved system of signalling now in use, a single track line can deal with much more traffic than formerly. At present, the St. Gothard Railway has single track sections, such as Brunnen-Fluelen, 12 kilometres (7·5 miles) long, with a passing place at Sisikon station, half-way; on the Monte Cenere line, there is even a section (Giubiasco-Riviera), 12 kilometres (7·5 miles) long, without a passing place. These instances show that the proposed Splügen tunnel, 26 kilometres (16 miles) long, with single track and three passing places, will be able to accommodate more traffic than is at present passing through the St. Gothard.

" The proposed system of construction is similar in principle to that proposed by Messrs. R. Weber and F. Hennings for long double-track tunnels, and which the author of this project already proposed last year, in connection with the suggested Faucille tunnel. When the definite plans are submitted, the details of this new system will be described; as regards the present application, all that has to be stated is that tunnel I will be for a single track line from the ends to the passing places, with a separate passage, made of masonry, below the level of the track. This passage will ensure ventilation during the construction of the tunnel, and allow any water struck to run out; it will also contain the water pipes (water for cooling and for the drills) and the many cables for the telephone, telegraph, signals, lighting, power supply, etc. In order to make it possible to provide for a second track or build a second tunnel later on without interfering with the service, the passing places will at each end be provided with a dead end, about 40 metres (44 yards) long, located in the future tunnel II, as shown in figure 3.

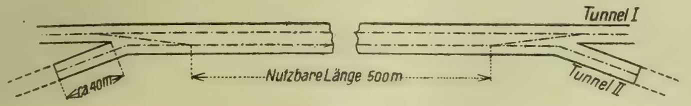


Fig. 3.

Explanation of German terms: Nutzbare Länge = Length available.

" The four tunnel sections, having an average length of about 6 kilometres (3·7 miles) each, can then be constructed and used, either simultaneously or successively. In order to accelerate the making of the headings of tunnel II the sections can, if required, be subdivided into any number of sub-sections, by putting in cross-drivers between tunnels I and II.

" The distance between tunnels I and II will be greater or smaller, according to the nature of the rock; this is a material improvement on the system adopted on the Simplon. There it was in fact found that the distance between tunnels I and II (17 metres [55 ft. $9\,{}^{5}/_{16}$ in.] between centre lines) was a suitable one for the greater part of the tunnel; it would have been so for nearly the whole tunnel if the geological expectations had been more fully realized. It would have been better for the other part to have a greater distance between the centre lines. Another important question is the carriage of the spoil and of the building materials. A new method is to be used for tunnel I, and eventually for tunnel II; it is expected materially to reduce the increase in the cost as the tunnel becomes longer.

" The Splügen tunnel II is to be constructed without bottom heading, because this is not required for the ventilation during construction and any water struck can if required be turned into tunnel I through one of the cross drives. As soon as both tunnels I and II are in use the passing places will under ordinary circumstances become unnecessary; but they can at once be utilized again if required, for instance if any of the eight sections require any important repair. From this point of view, the proposed system is much superior to a double-track tunnel; in addition to the economic advantages there is a great certainty that the construction can be carried out according to programme and will not be delayed in any way.

" Pressures similar to those which were found in the Simplon tunnel, 4·5 kilometres (2·8 miles) from the south end, might be fatal to a double-track tunnel. This pressure is much greater than that experienced in the St. Gothard tunnel, below Andermatt, where the stone work lining has been crushed in several times and has each time had to be strengthened; that this has not yet happened at the point mentioned in the Simplon, is due to the fact that the cross-section is for a single track and that the masonry is as thick as would be used in a double-track tunnel. It is by no means impossible, in deep Alpine tunnels, that greater pressures and stronger springs may be encountered than in the Simplon; geological science will never be able to forecast such conditions absolutely.

" The construction of two single-track tunnels is also advisable on financial grounds. Even if it is true that two single-track tunnels cost more than a double-track one, always assuming the latter to be practicable, yet there is an appreciable economy in favour of the single-track tunnel during the first period of construction, the most difficult financially; this economy, plus compound interest up to the time the second tunnel becomes necessary, fully outweighs the additional expense involved in building two single-track tunnels. When it is recognized that a second track is necessary, it is more rational to double the sections where this costs least, and to finish by doubling the tunnel, which costs most, than to proceed inversely.

" Near the north end of the tunnel, at Andeer station, the ground is naturally suitable for the important installations necessary; but on the south side, at Gallivaggio, considerable earthworks are necessary.

" The geological conditions of the proposed 26 kilometres (16 miles) tunnel have not yet been examined by experts and as yet no report is available on the subject. According to the opinion drawn up by Professor Alb. Heim on the 1890 Moser tunnel project, the conditions will not be unfavourable.

" It is estimated that the construction of the single-track tunnel will take eight years.

" The south end of the tunnel is near Gallivaggio, below the Virasco, a small torrent carrying much detritus, which will pass over the tunnel. Gallivaggio station, 798 metres (2,618 ft. 2 in.) above sea level, will be at the mouth of the tunnel; from there to Chiavenna, the track will follow the line proposed in the Moser 1890 project. Consequently the three helicoid tunnels, above Gallivaggio, proposed in the latter, will be left out. Between Gallivaggio and Chiavenna there will be intermediate stations at Pianazzola (height, 669·15 metres [2,195 ft. 5 in.]) and at San Croce (height, 543 metres [1,781 ft. 6 in.]). At Chiavenna, the Slpügen line will connect with the standard-gauge electric-traction Chiavenna-Colico-Lecco line, which continues in one direction *via* Milan to Genoa, and in the other *via* Bergamo to Venice.

" The steepest gradient is 26 per mil; the sharpest curve has a radius of 300 metres (15 chains).

" The track and the rolling stock of the Splügen line will be of the standard types laid down for main lines by the Federal Railway authorities.

" The trains will be hauled, as already stated, by steam locomotives and electric locomotives. The Chur-Rothenbrunnen section (steepest gradient, 10 per mil; radius of sharpest curve, 400 metres [20 chains]) is a valley railway; the trains arriving at Chur can without alteration run on to Rothenbrunnen. It will be simplest to haul them with steam locomotives, either belonging to the Splügen Railway, or to the Federal Railway, as long as the latter continues to use steam on the line down from Chur. Between Rothenbrunnen and Chiavenna, electric traction will be used. The use of self-propelled motor cars for international passenger and goods service, is evidently out of the question; whether individual cars of this kind can profitably be used for local passenger traffic is a doubtful question which the future will decide.

"It is at present unnecessary to trouble about the selection of the kind of electric current to use; any decision on this point can be put off until we know what results are obtained on the standard gauge lines which have been recently opened to traffic.

"The waterpower installations for generating the power for the electric traction, for which concessions have already been obtained on the Swiss side, and the electric equipment are considered in the preliminary estimates made."

As only to be expected, the application for the concession several times refers to the Greina railway, projected by Moser in 1905, and the Splügen railway, projected by Moser in 1890, and to the conditions existing on the St. Gothard line, for purpose of comparisons. We reproduce the more interesting results of these comparisons in tables I, II and III.

Table I.

Proportion of straights and of curves in percentages of the total length of the line, and comparison with the Moser, Splügen 1890, and Greina 1905 projects, and with the St. Gothard Immensee-Chiasso line.

RAILWAY.	Total length, in kilometres (in miles).	Curves having a radius of							Total.	
		280 metres (14 chains).	300 metres (15 chains).	301 to 400 metres (15·05 to 20 chains).	401 to 500 metres (20·05 to 25 chains).	501 to 700 metres (25·05 to 35 chains).	701 to 1,000 metres (35·05 to 50 chains).	More than 1,000 metres (50 chains.)	Curves.	Straights.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Splügen, 1906 application for concession.	83·892 (52·129)	...	13·7	4·6	1·5	1·8	4·8	6·0	32·4	67·6
Splügen, Moser's 1890 project	93·345 (58·003)	...	22·3	2·9	1·4	2·6	7·2	4·4	40·8	59·2
Greina, Moser's 1905 project.	96·955 (60·246)	...	...	20·6	3·2	2·2	2·3	1·3	29·6	70·4
St. Gothard, including Monte Cenere, 1882.	240·444 (149·408)	2·1	16·8	8·0	4·1	4·6	5·3	1·8	42·7	57·3

Table II.

Proportion of gradients in percentages of the total length of the line, and comparison with the Moser, Splügen 1890 and Greina 1905 projects, and with the St. Gothard Immensee-Chiasso line.

RAILWAY.	Total length, in kilometres (in miles).	Gradients, per mil.						Total.
		0 (on the flat).	2 to 10.	10·1 to 15.	15·1 to 20.	20·1 to 25.	25·1 to 27.	
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Splügen, 1906 application for concession.	83·892 (52·129)	7·8	37·0	0·7	17·0	10·3	27·2	100
Splügen, Moser's 1890 project	93·345 (58·003)	8·9	37·7	...	...	14·8	38·6	100
Greina, Moser's 1905 project.	96·955 (60·246)	13·3	51·8	9·9	...	25·0	...	100
St. Gothard, including Monte Cenere, 1882.	240·444 (149·408)	20·9	40·7	5·1	5·5	15·1	12·7	100

Table III.

Heights.

POINTS.	Splügen.		Greina, Moser 1905.	St. Gothard 1882.
	1906 application for concession.	Moser 1890.		
	Height, in metres.	Height, in metres.	Height, in metres.	Height, in metres.
Chur and Immensee stations	588·00 (1,929′ 2″)	588·00 (1,929′ 2″)	588·00 (1,929′ 2″)	463·00 (1,519′ ⅝″)
Rothenbrunnen, Cazis and Erstfeld stations .	626·00 (2,053′ 10″)	645·00 (2,116′ 2″)	...	476·00 (1,561′ 8½″)
Main tunnel, north end	1,000·78 (3,283′ 5½″)	1,080·00 (3,543′ 4½″)	902·20 (2,960′ 5/16″)	1,109·00 (3,638′ 6¼″)
Highest point.	1,040·00 (3,412′ 1½″)	1,155·60 (3,791′ 5″)	922·48 (3,026′ 6¾″)	1,154·55 (3,787′ 11½″)
South end.	800·75 (2,627′ 2″)	1,144·44 (3,754′ 9½″)	899·00 (2,949′ 6⅜″)	1,145·00 (3,756′ 7½″)
Chiavenna and Biasca stations	329·85 (1,082′ 2½″)	329·85 (1.082′ 2½″)	296·00 (971′ 1¾″)	296·05 (971′ 3¾″)
Length of main tunnel	26,135 metres (16 miles 422 yards)	18,640 metres (11 miles 1,026 yards)	20,350 metres (12 miles 1,135 yards)	14,984 metres (9 miles 547 yards)

As regards the estimated expenditure, the report states that the line is everywhere assumed to have a single-track, but that the land purchases include enough land for the second track. Similarly the great tunnel is to have a single-track line, except at the three passing places. The cost of the two approaches, per kilometre of line, agrees with that incurred on the St. Gothard line and with Moser's estimates (Splügen 1890, Greina 1905) ; the estimated cost of the Splügen tunnel is based on the cost of the Simplon tunnel.

Table IV gives a summary of the estimates compared with those of the Greina project; interest on capital during construction is allowed for.

Estimated cost of the Splügen 1906 project and of the Greina 1905 project.

Length in kilometres (in miles).	Splügen, Locher-Freuler's project, 1906.					Greina, Moser's project, 1905.				
	Northern access, 36·990 kilometres (22·985 miles).	Tunnel, 26·135 kilometres (16·240 miles).	Southern access, 20·767 kilometres (12·904 miles).	TOTAL.		Northern access, 49·500 kilometres (30·758 miles).	Double-track tunnel, 20·350 kilometres (12·645 miles).	Southern access, 26·800 kilometres (16·653 miles).	TOTAL.	
				83·892 kilometres (52·129 miles).	Per kilometre (per mile).				96·650 kilometres (60·056 miles).	Per kilometre (per mile).
I. — *Way and works :*	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.
a) General management and technical staff	649,710 (£25,988. 8*s*.)	4,000,000 (£160,000. 0*s*.)	519,175 (£20,767. 0*s*.)	5,168,885 (£206,755. 8*s*.)	61,613 (£3,966. 4*s*.)	752,000 (£30,080. 0*s*.)	3,989,250 (£159,570. 0*s*.)	618,200 (£24,728. 0*s*.)	5,359,450 (£214,378. 0*s*.)	55,400 (£3,566. 5*s*.)
b) Interest	371,490 (£14.859.12*s*.)	11,000,000 (£440,000. 0*s*.)	415,340 (£16,613.12*s*.)	11,786,830 (£471,473. 4*s*.)	140,500 (£9,044. 7*s*.)	398,000 (£15,920. 0*s*.)	7,920,000 (£316,800. 0*s*.)	528,000 (£21,120. 0*s*.)	8,846,000 (£353,840. 0*s*.)	91,500 (£5,890. 2*s*.)
c) Cost of land	695,550 (£27,822. 0*s*.)	...	519,175 (£20,767. 0*s*.)	1,214,725 (£48,589. 0*s*.)	14,480 (£932. 2*s*.)	990,000 (£39,600. 0*s*.)	...	536,000 (£21,440. 0*s*.)	1,526,000 (£61,040. 0*s*.)	15,800 (£1,017. 2*s*.)
d) Construction of the line	10,915,500 (£436,620. 0*s*.)	81,436,660 (£3,257,466. 8*s*.)	10,155,096 (£406,203.17*s*.)	102,507,256 (£4,100,290. 5*s*.)	1,221,895 (£78,656.11*s*.)	11,975,000 (£479,000. 0*s*.)	78,952,400 (£3,158,096. 0*s*.)	10,709,200 (£428,368. 0*s*.)	101,636,600 (£4,065,464.0*s*.)	1,051,600 (£67,694. 6*s*.)
1. Road bed	8,026,650 (£321,066. 0*s*.)	79,999,235 (£3,199,969. 8*s*.)	8,306,800 (£332,272. 0*s*.)	96,332,685 (£3,853,307. 8*s*.)	1,148,294 (£73,918.13*s*.)	9,016,000 (£360,640. 0*s*.)	77,650,000 (£3,106,000. 0*s*.)	8,890,000 (£355,600. 0*s*.)	95,556,000 (£3,822,240.0*s*.)	988,700 (£63,645. 4*s*.)
2. Superstructure	1,664,550 (£66,582. 0*s*.)	1,176,075 (£47,043. 0*s*.)	934,515 (£37,380.12*s*.)	3,775,140 (£151,005.12*s*.)	45,000 (£2,896.15*s*.)	1,985,000 (£79,400. 0*s*.)	1,221,000 (£48,840. 0*s*.)	1,062,000 (£42,480. 0*s*.)	4,268,000 (£170,720. 0*s*.)	44,200 (£2,845. 5*s*.)
3. Constructional works	1,039,350 (£41,574. 0*s*.)	...	809,913 (£32.396.11*s*.)	1,849,263 (£73,970.11*s*.)	22,043 (£1,418.19*s*.)	776,000 (£31,040. 0*s*.)	...	650,000 (£26,000. 0*s*.)	1,426,000 (£57,040. 0*s*.)	14,700 (£946. 6*s*.)
4. Telegraphs, signals, etc.	184,950 (£7,398. 0*s*.)	261,350 (£10,454. 0*s*.)	103,835 (£4,153. 8*s*.)	550,135 (£22,005. 8*s*.)	6,557 (£422. 2*s*.)	198,000 (£7,920. 0*s*.)	81,400 (£3,256. 0*s*.)	107,200 (£4,288. 0*s*.)	386,600 (£15,464. 0*s*.)	4,000 (£257.10*s*.)
II. — *Rolling stock*	1,479,600 (£59,184. 0*s*.)	1,045,400 (£41,816. 0*s*.)	830,680 (£33,227. 4*s*.)	3,355,680 £134,227. 4*s*.)	40,000 (£2,574.18*s*.)	1,980,000 (£79,200. 0*s*.)	814,000 (£32,560. 0*s*.)	1,072,000 (£42,880. 0*s*.)	3,866,000 (£154,640. 0*s*.)	40,000 (£2,574.18*s*.)
III. — *Furniture, tools and implements*	76,150 (£3,046. 0*s*.)	57,940 (£2,317.12*s*.)	41,534 (£1,661. 7*s*.)	175,624 (£7,024.19*s*.)	2,093 (£134.15*s*.)	99,000 (£3,960. 0*s*.)	20,350 (£814. 0*s*.)	53,600 (£2,144. 0*s*.)	172,950 (£6,918. 0*s*.)	1,800 (£115.17*s*.)
Totals.	14,188,000 (£567,520. 0*s*.)	97,540,000 (£3,901,600. 0*s*.)	12,481,000 (£499,240. 0*s*.)	124,209,000 (£4,968,360. 0*s*.)	1,480,581 (£95,308.17*s*.)	16,194,000 (£647,760. 0*s*.)	91,696,000 (£3,667,840. 0*s*.)	13,517,000 (£540,680. 0*s*.)	121,407,000 (£4,856,280.0*s*.)	1,256,100 (£80,858. 8*s*.)
Per kilometre (per mile).	383,563 (£24,690.19*s*.)	3,732,160 (£240,248.17*s*.)	601,000 (£38,687.19*s*.)	1,480,581 (£95,308.17*s*.)	...	327,151 (£21,059.11*s*.)	4,505,944 (£290,059. 7*s*.)	504,365 (£32,467. 6*s*.)	1,256,100 (£80,858. 8*s*.)	...

As regards the actual length, we extract from the application for the concession the figures contained in table V, where the Splügen line is again compared with the Greina line.

Table V.

True lengths, in kilometres (in miles).

	Splügen, Locher-Freuler's project, 1906.			Greina, Moser's project, 1905.		
From Chur to	Milan.	Genoa.	Venice.	Milan.	Genoa.	Venice.
Chur-Chiavenna	83·892 (52·129)	83·892 (52·129)	83·892 (52·129)	...	...	...
Chur-Biasca.	...	...	...	96·955 (60·246)	96·955 (60·246)	96·955 (60·246)
Chiavenna-Milan	117·000 (72·702)	117·000 (72·702)	...	...	...	...
Biasca-Chiasso.	...	...	...	74·300 (46·169)	...	...
Chiasso-Milan	...	...	...	52·000 (32·312)	...	...
Milan-Voghera-Genoa	...	151·000 (93·829)	...	...	...	...
Biasca-Luino	...	...	...	...	58·700 (36·475)	...
Luino-Mortara-Genoa	...	...	...	...	211·000 (131·112)	...
Chiavenna-Lecco	...	...	66·000 (41·011)	...	...	...
Lecco-Venice	...	...	267·000 (165·909)	...	...	267·000 (165·909)
Biasca-Como	...	...	...	...	...	79·300 (49·276)
Como-Lecco.	...	...	...	...	...	42·000 (26·098)
Total.	200·892 (124·831)	351·892 (218·660)	416·892 (259·049)	223·255 (138·727)	366·655 (227·833)	485·255 (301·529)
Kilometres (miles) round numbers	201 (125)	352 (219)	417 (259)	223 (139)	367 (228)	485 (302)
Difference in favour of Splügen	...	...	...	22 (14)	15 (9)	68 (43)

Finally, as regards the distances specified in the tariffs, the application states :

" In order to calculate the distances between Chur and Milan, Chur and Genoa, Chur and Venice, the extra mountain rate must be added for that part of the line which is in

Swiss territory, namely 50·925 kilometres (31·644 miles), whereas no extra mountain rate can be added for that part which is in Italian territory, namely 32·967 kilometres (20·485 miles), as the Italian tariffs provide for no such extra rate. In calculating the distance according to tariff on the Swiss side, two methods can be used, either that specified in the *Botschaft des Bundesrates* of September 11, 1873, or that applied on the St. Gothard. The first provides for an extra rate as soon as the gradients are from 10 to 15 per mil; the extra rate, which in those cases amounts to 19 per cent, rises to 62 per cent on gradients of 25 per mil, whereas on the St. Gothard there is no extra rate up to 15 per mil and the extra rate only amounts to 55 per cent on gradients of 27 per mil. We assume that the system applied in the case of the St. Gothard would also be applied, as would only be equitable, to the Alpine railway of Eastern Switzerland; from this we determine for the Splügen railway the following distances according to tariff, for the lines of traffic mentioned above :

"Of the 50·925 kilometres (31·644 miles) in Swiss territory, the Rothenbrunnen-frontier sections, tunnel included, having a length of 35·529 kilometres (22·077 miles), have gradients steeper than 15 per mil but less steep than 27 per mil; an extra rate of 55 per cent is applied to them, representing 35·529 × 0·55 = 19·541 kilometres (12·142 miles). The rated distance from Chur to Milan will thus be 200·892 + 19·541 = 220·433 (136·973 miles), from Chur to Genoa 351·892 + 19·541 = 371·433 kilometres (230·802 miles), and from Chur to Venice 416·892 + 19·541 = 436·433 kilometres (271·191 miles). According to the tariff regulations in force in Switzerland and Italy, this way of calculating the distances is absolutely correct; but as in the case of the Simplon, extra rates were admitted in the neighbourhood of the great tunnel, and as on the other hand, it is not certain whether the section with the extra mountain rate will commence, on the Swiss side, at Rothenbrunnen or at Thusis, we will take the most unfavourable case for the Splügen and assume that it begins at Rothenbrunnen and ends at Gallivaggio. We then obtain for the Splügen line an extra rate of 48·206 × 0·55 = 26·51 kilometres (16·47 miles), and the consequent following rated distances :

Chur to Milan. . . . . 200·89 + 26·51 = 227·40 kilometres (141·30 miles).
Chur to Genoa . . . . 351·89 + 26·51 = 378·40 — (235·13 —).
Chur to Venice . . . . 416·89 + 26·51 = 443·40 — (275·52 —).

On the Greina line, the extra rate would affect : the Somvix-Biasca section, tunnel 20·350 kilometres (12·645 miles) long, gradients of 15 to 25 per mil, 27·070 kilometres (16·821 miles) in length, together 47·420 kilometres (29·466 miles), which multiplied by 0·55 = 26·081 kilometres (16·206 miles); then the Biasca-Chiasso section (Monte Cenere), 16 kilometres (9·942 miles) according to the rates adopted on the St. Gothard; finally the Bellinzona-Luino section, with an extra mountain rate of 6 kilometres (3·728 miles). The Greina line thus gives the following distances :

Chur to Milan . . . 223·255 + 26 + 16 = 265·255 kilometres (164·825 miles).
Chur to Genoa. . . 366·655 + 26 + 6 = 398·655 — (247·717 —).
Chur to Venice . . 485·255 + 26 + 16 = 527·255 — (327·627 —).

“ The final comparison is as follows :

	Chur-Milan. Kilometres (miles).	*Chur-Genoa.* Kilometres (miles).	*Chur-Venice.* Kilometres (miles).
Greina project 1905	265 (165)	399 (248)	527 (328)
Application for Splügen concession :			
1. Extra rate to frontier.	220 (137)	371 (231)	436 (271)
2. — — Gallivaggio.	227 (141)	378 (235)	443 (276)
Difference in favour of Splügen :			
In case of No. 1	45 (28)	28 (17)	91 (57)
— No. 2	38 (24)	21 (13)	84 (52)

Indeed quite apart from the fact that no extra rate can be levied on the Italian side — the Splügen project must be more advantageous, from the point of view of the rated distances, than the Greina project, as in the latter line there are more alterations of gradient. The Splügen line has one ascending and one falling gradient, 1,198 metres (1,310 yards) ; the main Greina line 991 metres (1,084 yards), and the Monte Cenere, 380 metres (416 yards), together 1,371 metres (1,500 yards). Difference in favour of the Splügen, 173 metres (190 yards).”

The application for the concessions further considers the economic conditions, the possibilities of the traffic, the districts served and the relations of the Splügen line to the German Ocean and Adriatic canals, together with the Eastern Alps railways ; we do not propose to consider these details here.

[385 .113 (.4)]

REVIEW OF TRAFFIC QUESTIONS,

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(*Revue politique et parlementaire.*)

The railways in 1905-1906.

The results of working the railways during 1905 in France, England and Germany.

The official returns have brought us confirmation of the views we expressed here, in May 1906, as to the results of the year 1905 concerning the railways in the two great countries adjacent to and competing with France. The subsequent table gives the details. England, whose traffic had continued to grow in 1901 and 1902, while France and Germany were undergoing a kind of crisis, if not very serious, at least quite appreciable, only attained moderate increases in the following years; in 1905, these only amounted to 44 millions (£1,760,000) or 1·5 per cent of the receipts. In France, the increased earnings have been satisfactory, being as much as 62 millions (£2,480,000) or 4·1 per cent. In Germany, we find the upward bound of traffic enormous, an increase in gross earnings of 212 millions (£8,480,000) or 7·5 per cent.

If we take the whole ten-year period from 1896 to 1905, we find the growth of traffic has amounted, in France, to 298 millions (£11,920,000) or 23 per cent on the original figure, in England, to 590 millions (£23,600,000) or 26 per cent, in Germany to 1,060 millions (£42,400,000) or 53·5 per cent. It is true that in the interval the average rate per ton-kilometre fell in France from 5·12 to 4·52 centimes (0·8037*d.* to 0·6983*d.* per English ton-mile), a reduction of 12 per cent on the original figure, whereas in Germany the fall was only 7 per cent; this is continuing in France year by year, whereas in Germany, the average ordinary goods rate has been stationary since 1899; in England, there are no statistics to tell us the average rate. It is none the less true that the comparative increase in tonnage carried is, in Germany, double what it is in France and in England. But it must be noted that within the same ten years, the population has increased 8 million in Germany (15 per cent), nearly 4 million in England (10 per cent), only 800,000 in France (2 per cent); the production of coal has risen in Germany from 112 to 174 million tons (56 per cent increase), in England from 195 to 236 (21 per cent), in France from 29 to 36 million tons only (27 per cent). When arguing about the growth

Table I. *Results of working the main lines in Franc*

LINES AND YEARS		*France.* 1903	1904	1905	*England* (1). 1903	1904	1905
Average length open in kilometres (miles).		38,950 (24,203)	39,200 (24,358)	39,450 (24,514)	35,900 (22,308)	36,300 (22,556)	36,600 (22,742)
Results of working.		Millions francs. (Pounds sterling.)			Millions francs. (Pounds sterling.)		
Earnings	passengers	500 (20,000,000)	507 (20,280,000)	521 (20,840,000)	1,010 (40,400,000)	1,011 (40,440,000)	1,017 (40,680,0
	quick freight	168 (6,720,000)	179 (7,160,000)	185 (7,400,000)	201 (8,040,000)	210 (8,400,000)	213 (8,520,0
	slow freight	812 (32,480,000)	805 (32,200,000)	843 (33,720,000)	1,392 (55,680,000)	1,398 (55,920,000)	1,424 (56,960,0
	miscellaneous	24 (960,000)	24 (960,000)	28 (1,120,000)	197 (7,880,000)	203 (8,120,000)	212 (8,480,
	total	1,504 (60,160,000)	1,515 (60,600,000)	1,577 (63,080,000)	2,800 (112,000,000)	2,822 (112,880,000)	2,86 (114,640,
Working expenses		801 (32,040,000)	787 (31,480,000)	823 (32,920,000)	1,731 (69,240,000)	1,746 (69,840,000)	1,769 (70,760,
Net profit		703 (28,120,000)	728 (29,120,000)	754 (30,160,000)	1,069 (42,760,000)	1,076 (43,040,000)	1,09 (43,880,
Capital cost		17,275 (691,000,000)	17,442 (697,680,000)	17,571 (702,840,000)	26,600 (1,064,000,000)	27,140 (1,085,600,000)	27,48 (1,099,20
Interest on capital		4·08 p. c.	4·17 p. c.	4·30 p. c.	4 p. c.	3·97 p. c.	4 p. c.
Kilometric earnings in francs in £ per mile)		38,400 (2,472)	38,600 (2,485)	40,000 (2,575)	77,800 (5,008)	77,800 (5,008)	78,30 (5,04
Working coefficient (3)		53 p. c.	52 p. c.	52 p. c.	62 p. c.	62 p. c.	62 p.

(1) The capital is calculated on the securities issued allowing for the difference between the nominal amount and the carriage of mails which is done almost gratis in France and in Germany, and 9 millions francs (£360,000) from passenge expenses shown in the railway accounts each year, pensions to retired servants, inserted in Prussia in the finance b

of traffic in the different countries, it must never be forgotten that essential factors upon which it depends are the growth in conveyable materials, people and things, in number of consumers, and in production of coal, which is the foundation of all modern manufacturing.

The United States, where these items of traffic are developing still more rapidly than in Germany, show a growth of earnings far more marked than Europe. For the years closing on July 1, we find successive increased earnings of 715 million (£28,600,000) in 1902, 900 (£36,000,000) in 1903, 380 (£15,200,000) in 1904, 560 million (£22,400,000) in 1905. During the last ten-year period, the gross earnings have advanced from 5,957 millions (£238,280,000) in 1895-1896 to 10,790 (£431,600,000) in 1904-1905, an increase of 4,833 millions (£193,320,000) or 80 per cent. It is true that within the same time, the population grew from 70 to 83 mil-

ngland and Germany (official returns). **Table I.**

Germany (2).			INCREASE IN 1903 TO 1904.			INCREASE IN 1904 TO 1905.		
903-1904	1904-1905	1905-1906	France.	England.	Germany.	France.	England.	Germany.
52,400 (32,561)	53,400 (33,182)	54,400 (33,803)	250 (155)	400 (248)	1,000 (621)	250 (155)	300 (186)	1,000 (621)
Millions francs. (Pounds sterling.)			P. C.	P. C.	P. C.	P. C.	P. C.	P. C.
736 9,440,000)	770 (30,800,000)	825 (33,000,000)	1·4	...	4·7	2·8	0·6	7·2
106 (4,240,000)	113 (4,520,000)	122 (4,880,000)	6·5	4·5	6·6	3·3	1·5	8·0
1,675 7,000,000)	1,755 (70,200,000)	1,891 (75,640,000)	– 0·9	0·7	4·8	4·6	1·8	7·7
180 (7,200,000)	192 (7,680,000)	204 (8,160,000)	...	...	...	...	...	...
2,697 07,880,000)	2,830 (113,200,000)	3,012 (121,680,000)	0·6	0·8	4·9	4·1	1·5	7·5
1,708 8,320,000)	1,800 (72,000,000)	1,930 (77,200,000)	—1·7	0·9	5·4	4·7	1·3	7·2
989 39,560,000)	1,030 (41,200,000)	1,112 (44,480,000)	3·6	0·6	4·1	3·7	1·9	8·1
17,285 1,400,000)	17,725 (709,000,000)	18,190 (727,600,000)	167 (£6,680,000)	540 (£21,600,000)	440 (£17,600,000)	129 (£5,160,000)	360 (£14,400,000)	465 (£18,600,000)
5·72 p. c.	5·81 p. c.	6·10 p. c.	0·09	—0·03	0·09	0·13	0·03	0·29
51,400 (3,309)	53,000 (3,412)	55,900 (3,598)	200 (13)	...	1,600 (103)	1,400 (90)	500 (32)	2,900 (187)
63 p. c.	63 p. c.	63 p. c.	—1·4	...	0·3	0·2	...	—0·2

e price. The express traffic includes between 26 and 27 millions francs (between £1,040,000 and £1,080,000) derived from
ch is not levied in France. — (2) The financial year ends on March 31 each year. There has been added to the working
41 and 44 millions francs ([£1,520,000, £1,640,000 and £1,760,000]). — (3) Ratio of working expenses to earnings.

lions (19 per cent increase) and the production of coal from 171 to 319 million tons (87 per cent).

The increase in expenses in 1905 was proportionately a little less than the growth of earnings, in England and in Germany, slightly greater in France, where serious efforts towards economy had been made in the previous years. Everywhere the net profit increased perceptibly, to such an extent that the return on the capital involved in constructing the lines improved. It remained at 4 per cent in England where the railway capital expenditure has been very high; it reached 4·30 per cent in France, despite the comparative lightness of the traffic; it exceeded 6 per cent in Germany, where construction has been far easier and cheaper than in France, and in the United States, where it is true the capital has been markedly reduced by past defaults, on the one hand, and on the other hand by the custom of charging a lot of betterments to annual income.

Throughout the world, it was in 1905 that there were unmistakeable signs of the rebound that periodically follows times of depression. In 1906, the movement began to gather that giddy momentum which invariably brings about a crisis within a certain period. According to provisional estimates, it appears that earnings have risen by something like 100 millions (£4 millions) in England, 200 (£8 millions) in Germany, 1,200 (£48 millions) in the United States. Without offering any such wide oscillations as in countries where the heavy trade plays a preponderating part, France has profited from the movement in an appreciable measure, as is shown by the figures which appear in the second of our tables.

The results of working the French railways in 1906.

The increase, taking all things together, applied to all the railway systems and to all classes of traffic, as is shown by the figures appearing in table II. Two special reasons, however, prevented it from attaining as high figures as the general prosperity of business might have led one to hope. On the one hand, the Courrières accident and the strikes which succeeded it led to a serious decrease in the production of coal in the North and the Pas-de-Calais and the imports which made good the deficit, mostly brought by sea, did not provide our lines with as much traffic. On the other hand, the vintages of 1905 and 1906 were poor in quantity, especially in the Midi, and yet the fall in the selling price, which had followed the exceptional 1904 supply, continued, because the supplies derived from it were not yet exhausted. Thus, at both extremes of the country, the two most important items of traffic were heavily handicapped.

Decrease in long distance traffic of coal from the Northern districts, carried at very low rates, explains why the average rate per ton-kilometre has remained stationary from 1905 to 1906, although, as each year happens, a certain number of reductions in rates has occurred. Still it really seems as if suggestions for reductions were becoming less and less frequent, in face of the growing protests aroused by the confirmation of special reductions to meet individual trade conditions, and also by the new burdens imposed upon the companies by legislative enactments of which later on we quote two instances.

The growth in expenditure, though not entirely swallowing up that of the earnings, has been proportionately more marked than the latter, and for the first time, for a long while, the working coefficient has gone up slightly. This growth is due mainly to the causes that always make themselves felt when there is an exceptional glut of traffic. Fuel and all consumption materials rise in price at times of universal prosperity; as regards coal, the effects of the rise, which are usually subdivided over several years owing to the long run of contracts, was felt suddenly in 1906 when our Northern coalmasters were obliged to suspend the promised consignments, owing to the insuperable circumstances which blocked getting out the coal. When it is necessary to cope with unexpected needs by chance methods, to free stations as soon as possible and take care to forward consignments at once rather than load trains properly, when one has to throw in a fairly large number of inexperienced helpers, etc., it almost always happens that the extra traffic arriving unexpectedly costs more than it brings in.

Above and beyond these temporary causes, two legislative enactments have led to an extra expenditure that will recur regularly. The Rabier law which has negatived the clauses till now inserted in the special rates involving reductions of rate to lessen the liabilities of the carrier, means an increase in claims for damage — likely to increase still further if unscrupulous traders

Table II. — *Results of working the main French railways in 1906.*

RAILWAY SYSTEMS.	State.	Northern.	Eastern.	Western.	Orleans.	P.-L.-M.	Midi.	Secondary lines (2).	Totals and averages.	INCREASE	
										from 1904 to 1905.	from 1905 to 1906.
Average length open, in kilometres (miles)	2,910 (1,800)	3,800 (2,360)	4,900 (3,045)	5,850 (3,635)	7,650 (4,750)	9,450 (5,870)	3,800 (2,360)	1,550 (960)	39,600 (3) (24,600)	+ 250 (+ 155)	+ 150 (+ 93)
Results of working (1).	Millions francs. (Pounds sterling.)										
Earnings passengers	19 (760,000)	84·5 (3,380,000)	66·5 (2,660,000)	88 (3,520,000)	80 (3,200,000)	154·5 (6,180,000)	39·5 (1,580,000)	8·5 (340,000)	540·5 (21,620,000)	+ 14 (+ 560,000)	+ 19 (+ 760,000)
quick freight	7 (280,000)	25·5 (1,020,000)	22·5 (900,000)	23·5 (940,000)	33·5 (1,340,000)	68·5 (2,740,000)	11·5 (460,000)	1·5 (60,000)	193·5 (7,740,000)	+ 6·5 (+ 260,000)	+ 9 (+ 360,000)
slow freight	29 (1,160,000)	147 (5,880,000)	123·5 (4,940,000)	90·5 (3,620,000)	142 (5,680,000)	268 (10,720,000)	65·5 (2,620,000)	19 (760,000)	884·5 (35,380,000)	+ 38 (+ 1,520,000)	+ 40·5 (+1,620,000)
miscellaneous	0·5 (20,000)	4·5 (180,000)	3·5 (140,000)	6·5 (260,000)	2·5 (100,000)	7 (280,000)	4·5 (180,000)	1·5 (60,000)	30·5 (1,220,000)	+ 3·5 (+ 140,000)	+ 2 (+ 80,000)
total	55·5 (2,220,000)	261·5 (10,460,000)	216 (8,640,000)	208·5 (8,340,000)	258·0 (10,320,000)	498 (19,920,000)	121 (4,840,000)	30·5 (1,220,000)	1,649 (65,960,000)	+ 62 (+2,480,000)	+ 70·5 (+2,820,000)
Working expenses	41 (1,640,000)	136 (5,440,000)	116 (4,640,000)	119 (4,760,000)	125 (5,000,000)	249·5 (9,980,000)	58·5 (2,340,000)	22·5 (900,000)	867·5 (34,700,000)	+ 36 (+1,440,000)	+ 45·5 (+1,820,000)
Net profit	14·5 (580,000)	125·5 (5,020,000)	100 (4,000,000)	89·5 (3,580,000)	133 (5,320,000)	248·5 (9,940,000)	62·5 (2,500,000)	8 (320,000)	781·5 (31,260,000)	+ 26 (+1,040,000)	+ 25 (+1,000,000)
Payments to the State (4)	...	...	18·3 (732,000)	— 6 (—240,000)	9·7 (388,000)	...	0·1 (4,000)	— 7 (—280,000)	24·7 (988,000)	+ 16.5 (+ 660,000)	+ 8 (+ 320,000)
Annual capital expenditure chargeable to the companies	...	22 (880,000)	28 (1,120,000)	13 (520,000)	25 (1,000,000)	22 (880,000)	9 (360,000)	3 (120,000)	122 (4,880,000)	— 15 (— 600,000)	+ 50 (+2,000,000)
the State	16 (640,000)	1 (40,000)	7 (280,000)	4 (160,000)	10 (400,000)	18 (720,000)	8 (320,000)	2 (80,000)	66 (2,640,000)	— 5 (— 200,000)	+ 3 (+ 120,000)
Earnings per kilometre, in francs (in £ per mile)	19,000 (1,223)	68,800 (4,429)	43,800 (2,820)	35,600 (2,292)	33,700 (2,169)	52,700 (3,392)	31,600 (2,034)	19,700 (1,268)	41,600 (2,678)	+ 1,300 (+ 84)	+ 1,600 (+ 103)
Working coefficient (5)	74 p. c.	52 p. c.	54 p. c.	57 p. c.	48 p. c.	50 p. c.	48 p. c.	...	52·5 p. c.	...	+ 0·5
Distance run by trains (millions of kilometres [millions of miles])	18 (11·2)	58 (36)	51·5 (32)	53·5 (33·2)	53 (32·9)	83 (51·6)	25·5 (15·8)	9 (5·6)	352 (218·7)	+ 7 (+ 4·3)	+ 11 (+ 6·8)
Average rate per kilometre run passengers (centimes [penny per mile])	3·08 (0·4758)	3·65 (0·5639)	3·37 (0·5206)	3·38 (0·5222)	3·59 (0·5546)	4·03 (0·6226)	4·01 (0·6195)	...	3·59 (0·5546)	— 0·07 (— 0·0108)	— 0·04 (— 0·0062)
goods (centimes [penny per mile])	5·23 (0·8080)	3·86 (0·5963)	4·20 (0·6489)	4·93 (0·7617)	4·92 (0·7601)	4·57 (0·7060)	4·83 (0·7462)	...	4·52 (0·6983)	— 0·08 (— 0·0124)	0 (0)

(1) Figures from the accounts presented to the shareholders and not yet checked by the authorities; the figures relating to the Midi Company have been worked out from various statements of accounts to render them comparable to those of the other systems; some subdivisions are based on data that differ slightly from those adopted in the official returns, which explains why the differences inserted in the last column are not exactly those that would result from the totals given for 1906 in the present table, compared with those of the preceding table for 1905. — (2) The two Circle railways included; approximate figures. — (3) Allowance being made for joint running. — (4) Repayment of guarantee advances or share in profits; the sign — means advances made to the companies in default, on account of guarantee. — (5) Ratio of working expenses to gross earnings.

get into the habit, as seems possible, of taking advantage of the presumption that the company is to blame, even when an article already broken has been shoved into a consignment. The weekly holiday law, on the other hand, though not legally applicable to railways (whose business lends itself still less than any other to the application of uniform regulations), must necessarily force the companies to grant to their staff an increase in the days of freedom allowed at a regular interval, without its being possible for them to make good entirely this permanent decrease in the labour they get out of their men by abolishing the customary annual leave; under this head, the year 1906 has begun to be burdened with expenses that will grow very markedly in 1907. Lastly, the agitation which is being manifested throughout the working classes is not unnoticeable in its effects upon railway working; though such lack of discipline and attempts at coercion are, among this select staff, far from exerting such ravages as in many businesses and especially in State industries, yet we find in various ways some slackening in the zeal of the men, less keenness to do well, fewer attempts to cope with temporary difficulties, and the result is that the service is not only more costly but also less efficiently carried on.

Besides the increased cost of working there is a growth in capital charges. The expenditure chargeable to capital account reached the following amounts in 1906 :

Expenditure chargeable to the State	On budget credits	18	million	francs	(£720,000)
	Advanced to companies . . .	47	—	—	(£1,880,000)
Grants by local authorities		2	—	—	(£80,000)
Expenditure incurred by the companies	Grants for new lines	20	—	—	(£800,000)
	Additional works . . .	48	—	—	(£1,920,000)
	Rolling stock and equipment . .	54	—	—	(£2,160,000)
	Total. . .	189	million	francs	(£7,560,000)

The increase in expenses, 53 millions (£2,120,000) above those of 1906, related mainly to rolling stock. Far from exceeding the estimates of the companies, the purchases of rolling stock were well below the figures they would have wished to attain, owing to the foundries finding it impossible, overwhelmed as they were with orders, to accept new orders for rapid delivery, and even sometimes to deliver what they had promised within the time agreed. In 1906 the stock was increased by about 160 locomotives, 500 passenger carriages and 3,000 goods trucks and vans; to this must be added some thirty motor carriages, the trial of which seems to give satisfactory results and which will probably make it possible to improve greatly the service on unimportant lines by making it more frequent without unjustifiable cost. The orders given out, which will be filled in 1907 and 1908, reach the enormous total of 900 locomotives, 1,200 carriages and 31,000 trucks, involving an expenditure of between 200 and 250 million francs (between £8,000,000 and £10,000,000).

The cost of raising new capital has risen appreciably during the last two years, owing to the fall that has occurred in all securities with a fixed rate of interest, such as State funds; this is due to the large demand for capital on the part of industrial ventures and the high rate of interest they offer. The actual rate on debentures is on the average 3·60 per cent (on which about 0·25 per cent goes back to the State, in the form of income tax and stamp fees), whereas ten years ago the rate of interest was only about 3·20 per cent. Sinking fund charges, which added from 0·50 to 0·60 per cent only, when the time before the concessions ran out was still on the average about sixty years, now adds from 0·75 to 1 per cent because the interval is only from forty-four years (Northern) to fifty-four years (Midi). However the amount of the capital issues has been very reduced in 1906. In consequence of the losses experienced by the Orleans

Company in the Crosnier failure, the Government authorities have stimulated the companies to devote as far as possible their treasury balances to new works, instead of using them temporarily in contangos or in discounting bills and the comparatively low prices at which they could place loans has encouraged them to follow this line of action. The issues made by the whole batch of the great companies during 1906 did not exceed 65 millions (£2,600,000), while the sinking fund payments accounted for 163 millions (£6,520,000). The exhaustion of reserves, payment for large orders of rolling stock and for additional works necessitated by the growth of traffic, will oblige the companies to issue more capital this year and next, and if the money market does not improve, this borrowing will cost all the more, because it will force prices down further still.

All these reasons explain why, despite the excellent results of the year 1906, the general tone of the reports submitted to shareholders' meetings was not tinged with pronounced optimism and even displays some doubts about the future.

The Northern Company saw its net profits increase by 6 millions (£240,000) and raised its dividend from 68 to 72 francs (£2.14*s*. 5*d*. to £2.17*s*. 8*d*.), adding nevertheless 15 millions (£600,000) to its reserves; a further increase of 1 1/2 million (£60,000) would suffice to open up the era of sharing profits with the State. But the board expresses the fears inspired by the rise in the cost of fuel for the future of its earnings, expenses and the manufacturing industry of the districts it serves; this rise has doubtless been aggravated by temporary causes, but it appears to depend also upon a permanent cause that is becoming more marked each year — under the combined action of all the influences that are converging to diminish the duration and vigour of labour, the average output per day's work of the pitmen has fallen in the Northern and Pas-de-Calais mines from 1,120 kilograms (2,469 lb.) between 1895-1899 to 1,035 kilograms (2,282 lb.) between 1901-1905.

The most brilliant results are those of the Eastern Company; the gross receipts have risen 14 millions (£560,000), or 7 per cent, and net earnings 8 millions (£320,000). Doubtless the exceptional prosperity of the metallurgical industry, which has provided 250,000 tons extra for transport (on the top of an increase of 271,000 tons already realized in 1905), will only prove temporary. But the opening up of iron mines, conceded a few years back, means a source of lasting prosperity, and may some day render the Meurthe-et-Moselle district one of the main metallurgical centres of the world. At present the absence of local coal and the shortage of labour prevent the district from reducing more than a part of the ore extracted; another portion is consigned to the blast furnaces which some companies have preferred to put up in the northern districts, close to the coal mines : a further portion supplies our export trade and the richness of the beds makes it possible to develop this largely without compromising the future supply of our works, however much the latter may grow. The increase of 636,000 tons in the quantity of ore forwarded corresponds accurately with the estimates, but the proportion of this total transported a long distance has greatly exceeded expectations. The excess of earnings paid over to the State by the Eastern Company tots up to over 18 millions (£720,000), or 11 millions (£440,000) more than the annual interest on the advances it has previously received, and it can look forward with confidence to the extinction of its debt.

The Paris, Lyons & Mediterranean Company has also seen the returns of its line improve extraordinarily, with an increase of 23 millions (£920,000) in gross earnings and 8 1/2 millions (£340,000) in the net profit. The year 1906 benefited further by an exceptionally advantageous position of affairs, owing to the fact that a loan, whose sinking fund terminated in 1906, has left free an annuity of 4 $1/2$ millions (£180,000), and that the sinking fund applicable to the ordinary shares, which this annuity henceforth has to meet, does not begin till 1907. The company which last year was on the verge of the point at which it begins to share profits with the State, has had this year a divisible surplus of 14 $1/2$ millions (£580,000), of which it pays two-thirds over to the State. Out of the sums available consisting : 1° of the 10 millions (£400,000) difference between the guaranteed income and the income reserved before sharing; 2° of the third which belongs to it of the surplus beyond this latter, it has set aside 2 $1/2$ millions (£100,000) to increase its dividend by 3 francs (2*s.* 5*d.*) and the remainder to swell its various reserves, especially that for its pension fund.

If now we pass on to the companies serving the other half of France, that is the western side, we find a much less marked improvement in their position. Running through what are mainly agricultural districts, they hardly benefit from the extra traffic which is brought about by a manufacturing boom, but they do feel the effects of the rise in prices that accompanies it, so that in years like 1906 their increased expenses absorb almost of the whole of the increased earnings. More especially, in that particular year, the substitution of English coal, disembarked at the ports they serve, for the French coal which usually reaches them loaded on the Northern Company's trucks, forced them to run, with their own resources and their own rolling stock, a service for which in normal times they have nothing to provide except hauling power for trains reaching them ready marshalled; the result was to increase greatly the service difficulties and they gained nothing because the mileage run on their own lines was no greater.

The Western railways with 10 millions (£400,000) more in earnings, found its net profit only 1,700,000 francs (£68,000) greater. The very abundant crop of apples, more particularly, brought it in an increase of 900,000 francs (£36,000) in earnings: but this came from traffic that had to be carried within a very brief period, and caused great inconvenience by laying idle a lot of rolling stock, aggravated by the pernicious custom usual in this branch of traffic where the customary unit for sale is a 5 $1/2$ ton wagon load, which entails very moderate utilisation of the rolling stock. The call upon the interest guarantee fell below 6 millions (£240,000) and precisely because the improvement is not dependent upon the sudden boom in manufacturing, we may hope it will last. The company is deciding to undertake at its own expense the relief of the approach to the Saint-Lazare station, which the impossibility of settling the agreements under consideration has been delaying so long; it is putting down a third line between Bécon-les-Bruyères and Paris and it proposes to build a tunnel worked by electricity to serve the suburban district, carrying passengers under the present track to the *Cour de Rome* level, thus relieving the main line tracks. This scheme would mean an expenditure of some 30 millions (£1,200,000), the interest on which, if spread over several years, would have time to be covered by the extra receipts.

The Orleans Company has also realized nearly 11 millions (£440,000) more in earnings, with an increased expenditure of over 9 millions (£360,000), so that after allowing for first charges, the payment made to the State, for the repayment of its debt, is only 600,000 francs (£24,000) more than before. Nevertheless it is 3 $1/2$ millions (£140,000) in excess of the annual interest on its funded debt, so that the debit balance continues to come down slightly.

The Midi Company, contrasted with nearly 3 millions (£120,000) increased earnings has an increase in expenditure of over 3 millions (£120,000), half of which is due to the extra charge relating to pensions. Not possessing, like the Northern and the Paris-Lyons-Mediterranean, surplus earnings that it can set aside in good years to meet the deficiency in the mathematically calculated reserves of its pension fund, brought about by the improvement in the conditions and premium of pensions, it has found itself obliged to undertake to provide for contingencies by raising its contribution from 15 to 16 per cent on the wages, so as to prevent the deficit from growing any further, and by paying over a fixed annual grant of 1,400,000 francs (£56,000) to meet the deficit of the past. These new charges, coinciding with the crisis in the wine trade, cause a decrease of 300,000 francs (£12,000) in the net profit which just leaves the company the income requisite to avoid its again beginning to call upon the guarantee of interest.

The State system has a still heavier decrease in net profit, amounting to 500,000 francs (£20,000), despite an increase in gross takings of nearly 2 millions (£80,000). This is caused by the increase in expenses due to the all-prevailing causes that we have enumerated.

Despite these charges, three of the great companies are paying over to the State, out of the profits for 1906, a total sum of 37 ½ millions (£1,500,000), whereas one only calls upon the guarantee, and that for 6 millions (£240,000) only. Doubtless this period of prosperity will be followed, like the others, by a period of bad times, and on the other hand we see already appearing increases of certain charges owing to the new works and supplies of rolling stock requisite to carry on the service, for the weekly rest, etc. But the last year has already borne sufficiently heavy special charges to lead us to hope that its net profit does not correspond with any specially favourable situation. Moreover, the year 1907 commenced under favourable auspices. Even if we do not count fully upon the continuation of such high repayments as those which the Treasury received last year, we may hope that the era of deficits is closed, and that we have definitely entered upon the period, once regarded as chimerical, when the guarantee and sharing accounts of the great companies, which showed in 1893 a balance against the State of 100 millions (£4 millions), will show the State receiving a respectable sum, provided that no new law intervenes to add additional charges again to all those with which the working of railways has been loaded. Now that the State has so much difficulty in balancing its own budget, it would seem time that the Government should remember that it it has associates who work for its advantage by assuming in its place the unpopularity inseparable from measures of wise economy from which it reaps the benefit.

The crisis in traffic.

The present question, in the matter of traffic, which for several months has upset the commercial community, filled the papers and occupied parliaments, is that of the stock on railways and the delays resulting therefrom in the service. In this same review for November 1906 (¹), we made a few remarks on the subject and Mr. Dejean discussed the matter more fully in an excellent paper in the issue for March 1907. But we should be failing in the obligations imposed upon us by the very title of this review, if we did not return to the subject to-day.

The characteristic feature of this crisis is its generality. Those in favour of State working have seized this opportunity for blaming the companies, and the companies' organs have taken a vindictive pleasure in exposing the shortcomings of State working; the truth is that throughout the whole world, States and companies have found themselves coping with similar difficulties and have overcome them well or ill, more often ill than well, according to their individual resources and ability. We shall lay no stress on the facts pointed out in France, not in order to shirk them, but because they are not the ones that are likely to be forgotten at home. In Germany, in that

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(¹) See *Bulletin of the Railway Congress*, No. 4, April 1907, p. 457.

pattern country of State working, complaints are universal and the Minister for Public Works in Prussia was obliged, in the budget debate, to acknowledge that they were well founded. Already, in the preceding winter, his predecessor had confessed that the service was in unprecedented confusion, and this winter the situation was no better; the coal-owners affirmed that there was no assurance that their consignments would be forwarded and there were even some who requested leave from their French customers to deliver English coal by sea, for lack of trucks to despatch them German coal. We take at random from official publications statements such as the following :

From November 1 to 15, 1906.

Ruhr	mines,	out of	287,728	trucks required,	there lack	32,889,	or 11 p. c.
Silesian	—	—	102,092	—	—	12,251,	or 12 —
Sarre	—	—	34,289	—	—	1,206,	or 3.5 —

In March 1907.

Ruhr	mines,	out of	613,016	trucks required,	there lack	53,696,	or 9.4 p. c.
Silesian	—	—	204,243	—	—	11,487,	or 5.6 —
Sarre	—	—	71,750	—	—	7,571,	or 10.6 —

Over the whole Prussian railway system.

October,	1906,	out of	1,228,343	covered	trucks required,	there lack	76,869,	or 6 p. c.
—	1906,	—	2,223,989	open	—	—	189,603,	or 8 —
February,	1907,	—	1,574,668	covered	—	—	43,706,	or 3 —

In Austria and in Hungary, some mines were on the point of closing down, some works had to be shut, for want of means of transport. In Belgium, traders and passengers continue to cry out. And if we take in the other hemisphere the country where company working enjoys the most extensive liberty, we find that in the United States there is a clamour on all sides against the inability of the railways to give a proper service, enquiries are opened on the causes of the trouble and the remedies necessary. But in this wholesale competition, the palm belongs unquestionably to Italy. Not doctrinally, but because they could not come to terms with the leasing companies to prolong their tenure, the State took over the working of its railways in 1905; forgetful of the proverb, it changed horses, if not in mid-stream, at least on entering the water, just when the boom in industry in Lombardy and the approach of the Milan exhibition made exceptionally heavy traffic probable. The impossibility of coping with it, the resulting confusion, the block in Genoa where half the goods disembarked had to lie unattended to, and the closure of works for lack of fuel, are facts universally known.

The universal character of the crisis depends upon the fact that the *causa causans* is itself universal; it is in fact the return of great activity in business which comes periodically with the regularity of the swing of a pendulum, and the coincidence of which throughout the whole world becomes more and more precise in proportion as the facility of communications renders the dependence of markets upon each other more complete. It should be added that, now that railway traffic possesses an international character, as soon as the crisis becomes somewhat acute at any one point, it necessarily leaves its mark : countries which are short of rolling stock do not resist the temptation of using the tracks that reach them loaded from foreign countries, instead of returning them immediately empty or full; those whose stations are blocked keep at the frontier trains which would accentuate this block still further, blocking in their turn thus the roads of their neighbours and laying idle their rolling stock. The Paris-Lyons-Mediterranean thus felt the effects at Modena of the confusion reigning in Italy, and Austria was on the point of ceasing sending trucks to Italy.

If the crisis returns periodically, some one will say, nothing can be easier than to foresee it and make provision ahead. To a certain extent, that is true. The able investigations of Mr. Juglar have established the regular character of the waves of prosperity and of stagnation in business, and experience proves this law with astonishing precision. We have stated frequently that it would be wise on the part of railways to provide themselves beforehand with rolling stock, when the works would be only too happy to work for them at low prices and not expose themselves to the risk of having to give out late, when prices are at their highest, orders which often will not be filled until the need is past. Dare we say it? The enormous orders under execution, instead of reassuring us, frighten us a little.

We know well that under pressure of the inspecting department, in face of the public clamour, the companies have no other way of shifting their responsibility, in times of traffic blocks, than to prove that they have hammered at all doors to increase their equipment. But in order to arrive at giving out their orders regularly, it is not a wiser way to overdo them during times of stress than to stop them when requirements slacken. In 1905, the Prussian Minister of Public Works, in order to excuse his management for not having bought during the lean times of 1901-1902 the rolling stock that he needed when times got better, recalled the plethora in which it found itself at that moment; having received delivery, towards the close of the preceding period of activity, of trucks ordered to meet to previous deficiency, they had to build sidings to accommodate the idle trucks. We had a similar experience in 1885 and 1886. It is to be feared that about 1908-1909, when all the rolling stock so impatiently awaited to-day is lying idle, orders will have to be stopped and that then, forgetting the noble resolutions everybody is now making for the future, they will delay too long in beginning to give out orders.

And it is not only trucks that are deficient; everywhere professional men say that the fault lies less in the want of sufficient rolling stock than of siding and sorting yards, plant suitable for hastening the handling and marshalling of the trains. In a remarkable article recently published in the *Revue du Mois*, Mr. Labastie showed how the rapid rotation of rolling stock possesses as much and more importance than the increase in its quantity and what difficulties this offers. As regards fixed plant too, it is during the peaceful times of stagnation that preparations ought to be made to carry on the war against coming difficulties. But in that case, forecasts are more uncertain; it is not sufficient to know that a recovery will surely come; one must know, moreover, at what points the new requirements will appear, and there is a serious risk, in putting down equipment beforehand, of not doing it at the right place.

But, do what one may, it will always be financially impossible to provide railways with enough equipment to make the service run as well during times of exceptional business activity as in normal times. No country could stand paying interest on such an exorbitant capital. Every paper has been quoting a conversation in which one of the American railway kings, Mr. Hill, estimated 1,100 million dollars (£220 millions) per annum for five years as the sum requisite to put the railways of the United States in a position to meet their requirements. As we have not seen the original statement, we do not know whether Mr. Hill was posing as an ironical cynic or as a bragging millionaire; but it is anyway true that even if he lived among a group of financiers who could in five years find for the American railways the 28 milliards (£1,100 millions) he wants, the contractors and labourers able to get through the money in so brief a time, provided only a pause ensued at the end of the five years, at the very first moment of revival that followed there would be a deficiency of rolling stock or staff or plant at some point or other. It is not possible always to keep standing idle but ready the equipment requisite to meet the maximum needs which will arise during one or two seasons, during the eight or ten years of the cycle which brings the periodical crises. The only reasonable method in practice is to regulate the growth of staff and equipment according to the average increase, and to cope with sudden increase of traffic by a sudden surplus of energy.

But at the moments when this surplus is necessary, any accident is enough to bring about serious trouble. For a little time, one can get from the staff and from rolling stock exceptional work. But suppose at a certain point, the abundance of traffic renders it impossible to balance the outgoing and incoming consignments, then promptly the lines get blocked and rolling stock accumulates; it is no longer possible to clear the loaded trucks and take them to the point where they ought to be unloaded; there is no longer time to arrange them once they are empty to suit requirements, to marshal them when they are reloaded, so as to fully utilize the tractive power of the engines; one has to resort to pooling engines, running the same locomotives constantly with different crews, instead of leaving each under the control of the same driver who is responsible for its condition; being less carefully inspected, despatched less often to the shops, because they cannot be dispensed with, the engines end by causing more irregularities and breakdowns in the service. Soon the work got out of them, instead of growing with requirements, decreases, and the difficulty of dealing with the increased traffic becomes an impossibility.

To escape this calamity, it is necessary, from the very commencement of periods of activity, to make demands upon everybody's goodwill and overwork the indolent a little. It is no longer upon the railway company that the public authorities can usefully make demands at this moment; naturally they intervene to keep it up to the mark during periods of stagnation, but at extra busy times, the needs it has to meet, and the responsibilities it incurs stimulate its zeal better than any abuse. Then it is the consignors and consignees who mustbe urged to facilitate the promptness of the public service, by cutting down, for instance, the time they are allowed for loading and unloading wagons when this business depends upon them. Under these circumstances, the position of companies is always more difficult than that of State systems, because the latter have always backing them public authority of which they are an emanation, whereas between the companies and the public, the inspecting department naturally tends to side with the public whose representative it is. During the present crisis, we have seen the Government, in Italy, frequently suspend consignments to such or such overcrowded points, — in Austria, suspend for several days the ordinary goods service between Vienna and Galicia, — in Hungary, suspend entirely the consignment of goods from January 28 to February 8, — in Belgium, close the frontier on the 30th and 31st of January, etc. In France, the companies could not get leave to make a few alterations they asked to be allowed to make temporarily in the regulations.

Not only has the State not come to their aid, but it has singularly aggravated their position by the law on the weekly rest-day. It is true, the law is not applicable to the railways; but by stopping entirely the loading and unloading by private persons on Sundays, both at stations and on private sidings, it has seriously delayed the liberation of a number of trucks. Those in favour of State intervention in the working of railways, frequently support their theories by adducing the necessity of alleviating periodic crises which give rise to speculative commitments; the moment selected for applying the new law is a typical instance of the small amount of foresight with which public authorities, when they intervene in economic phenomena, do it in a manner most likely to aggravate crises instead of alleviating them. Whatever opinions one may hold about the utility of measures which limit the hours of labour, it must be acknowledged that the act of putting them into force must always bring about transitory difficulties; the latter become particularly prominent when there is a scarcity of labour everywhere, as at the present moment. If originally applied at a time when the number of those involuntarily idle was considerable, the law on the weekly rest-day might have decreased distress, by obliging manufacturers to make good the decrease in days of labour by an increase of their staff; then, until the next revival, industry would have had breathing space to accustom itself to the new regime. The wise thing would be even to suspend or temporarily alleviate the stringency of laws of this kind, when hands are everywhere deficient; but by putting them into force just at these times, the legislator aggravates the difficulties of the service of which he then makes a grievance to traders.

Despite these difficulties, it really seems as if France is one of the countries in which the recent crisis was least felt. As far as can be judged, except in the case of England, which appears to have almost entirely escaped it, all the manufacturing countries have suffered more than we have. Our railway systems are, moreover, among those best supplied with rolling stock, considering their traffic. The statistics most recently issued show clearly from this standpoint the difference between our position and that of Germany.

1905.	*France.*		*Germany.*	
Number of goods wagons.	289,857	...	442,374	...
Total capacity of wagons (in tons [in English tons]).	3,217,000	(3,166,000)	5,788,000	(5,697,000)
Distance goods carried (millions of ton-kilometres [millions of English ton-miles])	17,676	(10,810)	40,519	(24,780)
Number of wagons per million of ton-kilometres (per million of English ton-miles)	16·3	(26·7)	11·2	(18·3)
Number of tons of wagons capacity per million of tons	182	...	143	...

In view of these figures, no one has a right to say that our companies equip themselves less to meet the requirements of the public than the German State railways. The main difficulty in their management is the lack of elasticity in the regulations upon which we have insisted in this review on many former occasions. The intervals allowed under our special tariffs are certainly excessive in normal circumstances; but they equally apply in critical times, whereas in Germany, a railway is only bound to supply rolling stock as and when it is at liberty. Of course we have no desire to see extended to France a regime under which the public is at the absolute discretion of the railway administration; but to grant some relief in the obligations of the companies in times of stress, to subject their customers to some hardships in order to set at liberty the rolling stock, would not be asking too much, and as some compensation for these easements, the time limits might be decreased under normal circumstances, once it was understood that lack of fulfilment did not render the company liable when it was due to an abnormal increase of traffic.

Our whole legislation is based on the notion that the railways ought at all times to insure under similar conditions the carriage of all the traffic entrusted to them; but this idea is contrary to the very nature of things. Unquestionably, railways, being invested with a monopoly, cannot be left free to grant or refuse their services according to their convenience, and it must be assumed as a principle that they are bound to meet all demands, so long as a judge has not decided that they were prevented by a case of *force majeure.* But in order that the exceptional growth of traffic, at times of extreme business activity, may not produce this *force majeure*, it is essential they should be given all the facilities compatible with the requirements of the public. No industry in the world, no traffic organisation whether by land or water can be so equipped permanently as to satisfy all the clients who may offer themselves at a busy time in the same manner as in normal circumstances. When the blow comes, railways submit to the terms of their contractors who only accept such orders as they can carry through; railways too have to accept all the traffic that their usual competitors, barges and coasting boats, refuse for lack of room; at least they should be helped to accommodate it.

In insisting upon these considerations, we certainly do not intend to entirely shift the responsibility from the shoulders of the companies in the present crisis. We have often enough affirmed and re-affirmed that it would be wiser on their part not to reduce as much as they often have done, the purchases of rolling stock in lean years. It is during these years that it would be well to remind them of the advisability of these measures of precaution. What is requisite at times of crisis, owing to superabundance of traffic, is to help them through with it, and not forget above all things that crises of this kind are an inevitable consequence of the irregularity of business, that all countries suffer therefrom like ours, and that we have been far this year from being the worst hit.

MISCELLANEOUS INFORMATION

[621 .33]

1. — Special electric train on the Lancashire & Yorkshire Railway.

Fig. 1, p. 839.

(*Engineering.*)

During the year of 1906, the sphere of electric traction was extended on the Lancashire & Yorkshire Railway to include Aintree, thus adding to the mileage worked electrically by some 5 or 6 miles of road. This extension is expected ultimately to prove of considerable benefit, for Aintree, situated to the north-west of Liverpool, is not only a growing residential suburb of that city, but is also of importance as the scene of the *Grand National.* At such times as race meetings, the railway company has, of course, to cope with a considerable amount of special and extra traffic, and on the occasion of the Spring Race Meeting, held on March 21 to 23 last, such special trains from Liverpool were for the first time all worked by electric power. The specials were six in number, and were probably the longest and heaviest electric trains ever run in this country, taking the place of steam trains of similar capacity. A distinct advantage in the handling of such traffic is obtained with electric trains, for while with steam trains it was necessary at the end of each journey to do shunting operations in order that a fresh locomotive may be attached to the train for the return journey, such work is obviated with the electric trains.

Four of the special trains used on the occasion to which we have referred, consisted of ten ordinary six-wheeled trailer carriages, over the roofs of which cables had been run to connect standard electric motor-cars, placed one at each end. Of one of the trains we give an illustration (fig. 1). The motor-cars are 60 feet long, and are each equipped with four 150-horse-power motors. By trains made up in this way, the company were enabled to utilise a considerable amount of ordinary stock. The other two trains were made up of stock having a similar capacity, but using ordinary electric trailer carriages. The horse-power of each train nominally can be taken to be 1,200, both sets of trains being approximately 460 feet long, each capable of seating over 500 passengers, and weighing about 230 tons.

[625 .232]

2. — The first steel Pullman sleeping car.

Figs. 2 to 4, pp. 839 and 840.

(*The Railway Age.*)

The steel sleeping car, which the Pullman Company recently completed, has attracted unusual attention from railroad officers, not only because the car is constructed entirely of metal, but on account of the decorative features which have all the beauty of graceful outline and pleasing color treatment which are characteristic of recent Pullman cars built of wood. This is true not only of the interior finish but of the exterior, where the simple straight line scheme is carried out in such pleasing proportions, especially in the window treatment, that the steel car may well serve as a model for wooden cars in this respect. The car has already been on private exhibition at the Broad street station of the Pennsylvania in Philadelphia, and at the Grand Union station of the New York Central in New York City. It is named " Jamestown," as it is intended to be placed on exhibition at the Jamestown exposition during the summer.

In the construction of the car, it was the intention of the builders to make it fireproof by the entire exclusion of wood, and the framing throughout is of steel and the finish is steel, aluminium or brass. The underframe is made up of two 15-inch I-beam center sills with $^1/_2$-inch cover plate on top only, and these beams are continuous through to the end sills. The center sills are trussed with $1\,^7/_8$-inch rods upset for $2\,^3/_8$-inch turnbuckles. For the side construction is a $^1/_4$-inch plate about 30 inches deep, which forms the side sheeting of the car below the windows. This plate is stiffened at the lower edge with a 6 by 6 by $^1/_2$ inch angle, which is continuous between end sills. The upper member of this girder is a 3-inch steel bar outside and the side posts are offset around it. All the rivets in this side sheeting are countersunk and the whole surface is smoothly finished. The body bolster is double and made of a steel casting integral with the end sill and platform beam, draft sills, center plate and side bearings. This large casting combines within itself practically all of the end of the underframe. It was furnished by the Commonwealth Steel Company. There are four cast-steel cross bearers spaced equally between the body bolsters, and each is cast in one piece, extending between the side sills. Extending between the cross bearers there are floor beams, which are made of 4-inch channels, laid with the web horizontal. The side posts are made of 4-inch I-beams, two for each wide pier, and a single beam for the narrow piers. These posts are continuous from the side sill to the plate, the upper part forming the carline for the side deck. The pier covers in the side finish between windows are 1-16-inch steel plate and are put on with countersunk rivets.

The deck sill consists of a T-iron extending continuously between the body end plates, and is secured to the ends of the side post, thus forming the carlines of the side roof. The carlines in the upper deck are 1-16-inch pressed steel of channel section, and they also form the deck posts at the double piers, but at the narrow piers the deck posts are flat bars. The purlines are 1-16-inch pressed steel in channel shape and the roof is of galvanized iron with copper flashing. There are two end posts of 4-inch I-beams located under the deck sill and secured to it and to the body corner post; at the bottom they are fastened to a 4 by 4 inch angle, which is riveted to the body end sill casting.

The platforms are fitted with the Forsyth buffing device and radial centering device, and the couplers are fitted with the Westinghouse friction draft gear. There is a double floor construction, the deadening floor being placed on top of the cross bearers and floor beams, and above this is the floor of the car formed of monolith cement laid on corrugated iron of Keystone section. The insulating material in the sides and ends consists of two thicknesses of asbestos board placed between the sheeting and extending from the side sill to the side plates. This construction has contributed materially to making the car ride

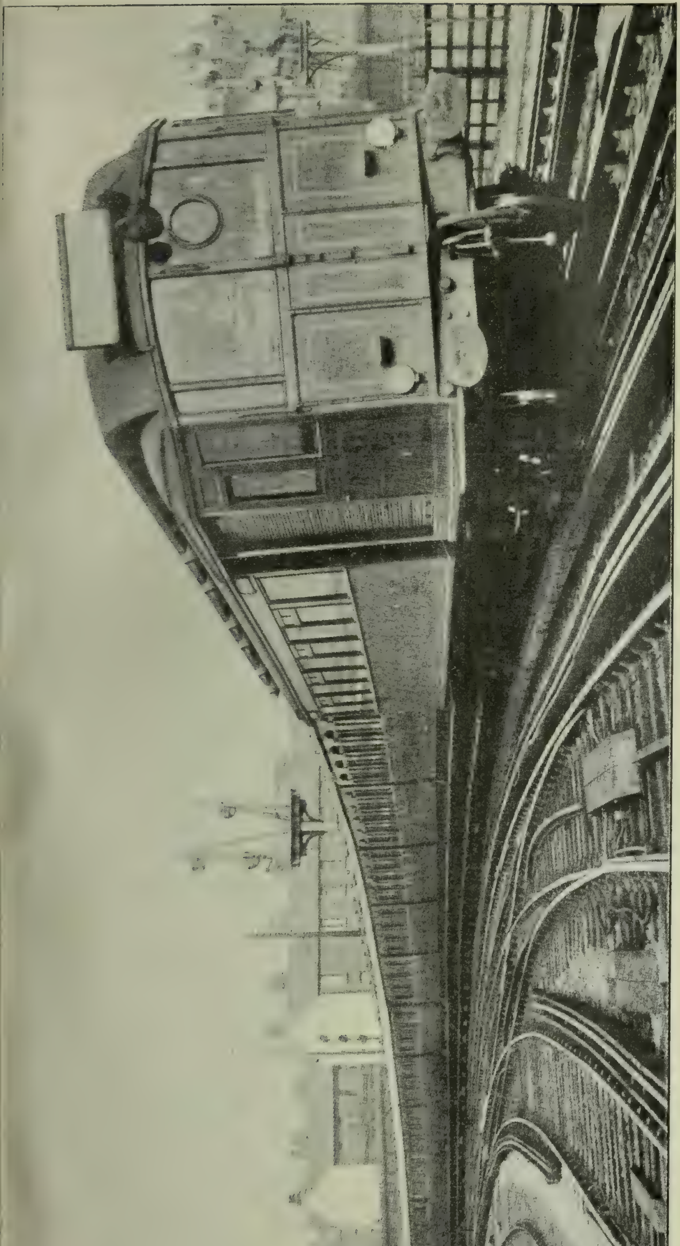
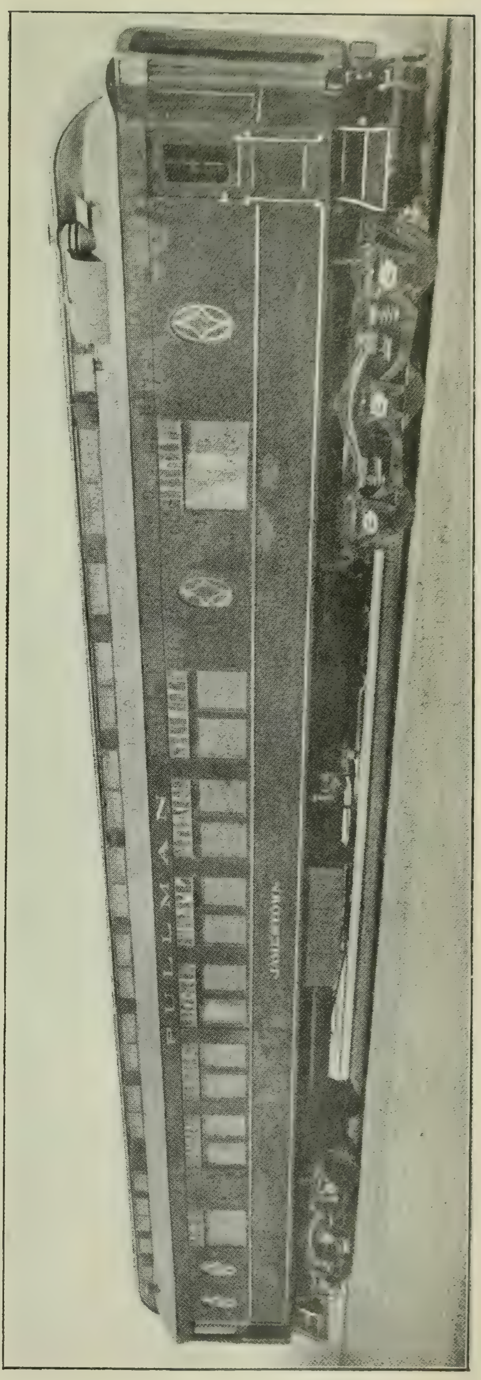


Fig. 1. — Special electric train on the Lancashire & Yorkshire Railway.



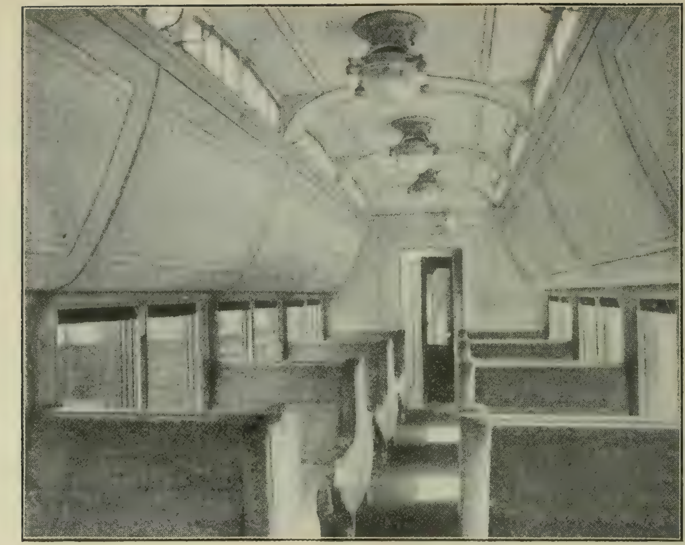


Fig. 3. — The first steel sleeping car.
Interior view of the main body of the car.

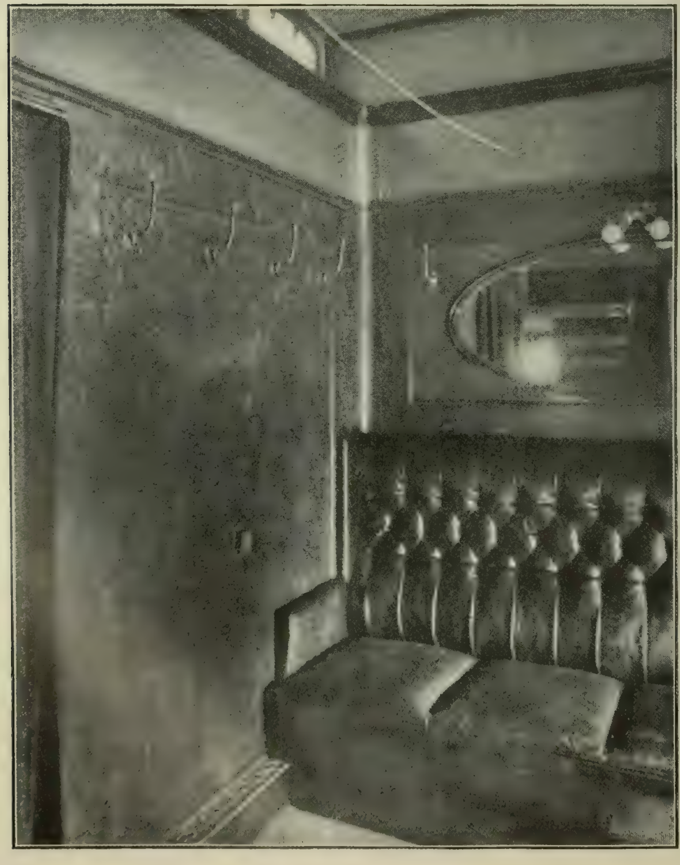


Fig. 4. — The first steel sleeping car.
Interior view of men's toilet room.

very quietly and it will also overcome the objection to steel construction in preventing any discomfort due to extremes of heat and cold. The seat frames are of pressed steel. The plush seat cushions and the carpet are of old rose color. The window sashes are made of brass. The side panelling is of steel plates, pressed with simple moldings. The upper deck is of aluminium in semi-empire style. The lower deck ceiling is of composite board and the berth fronts are made of thin steel sheets. All this inside metal work is painted a pearl gray with gold ornamental lines.

The trucks are of the standard Pullman 6-wheel type, but have cast-steel frames and bolsters, supplied by the Commonwealth Steel Company. The wheels are 38-inch Paige with Latrobe steel tires. The axles are M. C. B. standard with 5 by 9 inch journals, and the brakebeams are the Diamond special. The brakes are the Westinghouse high-speed, with a braking power equal to 90 per cent the weight of the car.

The design and construction of a Pullman car entirely of metal was a very difficult problem and the Pullman Company is to be congratulated upon the very successful result of its first attempt to produce a fireproof car.

The principal dimensions of the car are :

Length over end sills	72 ft. 6 in.
Length over platforms coupled	80 ft. 6 in.
Width over side sills	9 ft. 9 $^1/_4$ in.
Height over all	14 ft. 7 in.
Width over all at eaves	10 feet.

[656 .257]

3. — New arrangement for electric working of signals and switch-points, in use at the Courcelles Station of the Ceinture Railway, Paris.

Figs. 5 to 14, p. 842 to 845.

(*Revue générale des chemins de fer et des tramways.*)

The main characteristic feature in the new electric apparatus for working signals and switch-points, which has been in use experimentally for some time on the Ceinture Railways, is the use of a " sectional " electro-magnet.

Whereas single wound electro-magnets only permit of very short strokes, involving disadvantages as regards direct action on the switch-points and signals, the new arrangement gives, so to speak, an unlimited stroke. Moreover, single wound electro-magnets only give the minimum of their power at starting, the maximum being attained at the end of the stroke, when a weak effort would suffice to bring the switch to the locking point ; it is therefore necessary, for the purpose of starting, to increase the number of " ampere windings " ; and this entails somewhat cumbersome apparatus, and generally necessitates rather complicated arrangements for minimising the effects of self-induction.

The new apparatus, designed by Mr. Guedon, chief inspector of the Ceinture Railways, differs according to whether it is intended for working a signal or a switch point.

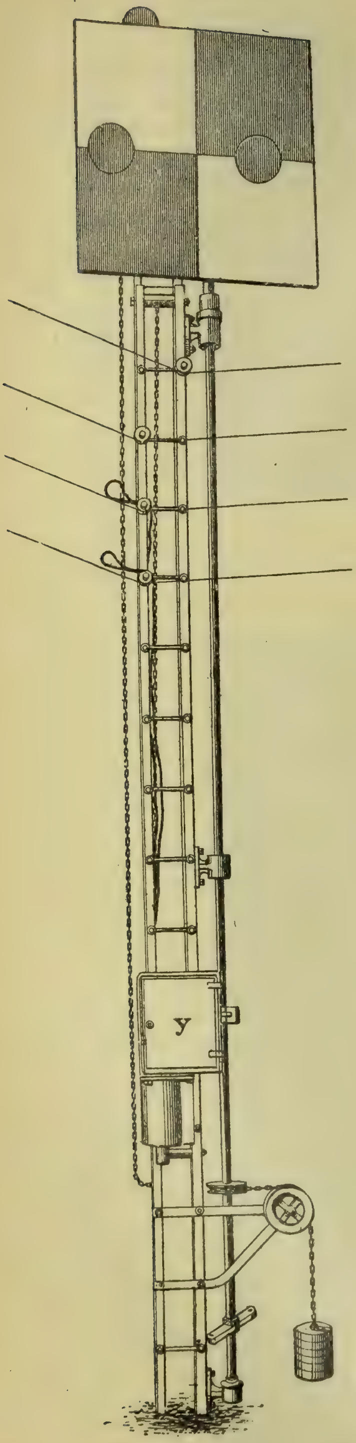


Fig. 5.

a) APPARATUS FOR ELECTRIC SIGNAL WORKING.

The apparatus is enclosed in a box Y, of small dimensions, which may be fixed at any height on the signal post, by means of four bolts (fig. 5). This box is closed hermetically by a hinged door resting on a rubber-lined frame.

The whole arrangement consists of an electro-magnet A, arranged in sections, formed of four coils, a core B, and a pulley C, on which a chain is wound, and a special electro-magnetic " retaining " system (fig. 6 and 7).

Behind the pulley C, a plate, with contact-pieces, successively closes the circuit of each disk-shaped coil, called " galette " on account of its shape, and towards which the core B is directed. It will be seen, from the diagram (fig. 8), that the coil, when it has just been excited, is short circuited, which completely suppresses any sparking on the plate while in action.

The pulley and the plate are keyed to a spindle *c*, projecting from the box on the side opposite the door and having on the outside a pulley c^1 of lesser diameter, on which is wound a wire-cord 12 to 15 centimetres ($4\,{}^{23}/_{32}$ to $5\,{}^{29}/_{32}$ inches) in length, acting on a grooved sector close by keyed direct to the actual spindle of the signal to be worked.

The pulley C has a " scroll " cam c^4 which, when stationary, that is when the signal is at " danger ", applies a lever E, working round the axis *e* to a " retaining " electro-magnet E^1.

The pawl *f*, of lever F, which pivots on an axis *x*, falls into a slot c^6 arranged on the periphery of the pulley, as the latter revolves.

This part F, by means of the articulation g^1, operates the quick-break carbon-switch G, thereby establishing communication between the line and the coils of electro-magnet A.

On the other hand, the coils of the " retaining " electro-magnet E^1 are always " on shunt " on the main circuit.

The electric working of the signal only acts in one direction to put it at " line clear ", it being brought back to " danger " by a counterweight, as soon as the action by which the signal is lowered ceases.

When the signal is to be lowered, the circuit of that signal is closed in the signal box by means of a lever on the special switch; at the same time the current passes into the " retaining " electro-magnet E (permanent shunt), and in the principal electro-magnet A, through the switch G, the core being successively attracted by each of the " galettes " (*see* diagram, fig. 8), descends slowly, pulling the chain, thus turning the large pulley C, and with it the outer pulley, which acts on a sector keyed on the signal axis; the sector turns to an angle of 90°, and the signal sets at "line clear".

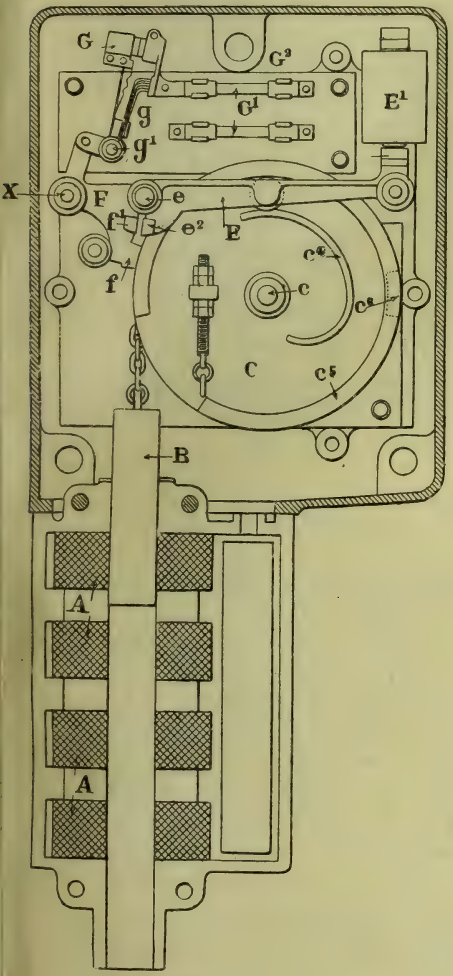


Fig. 6.

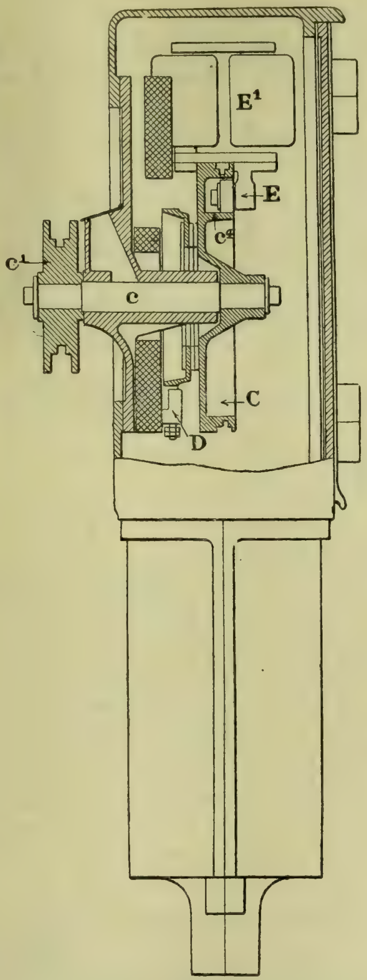


Fig. 7.

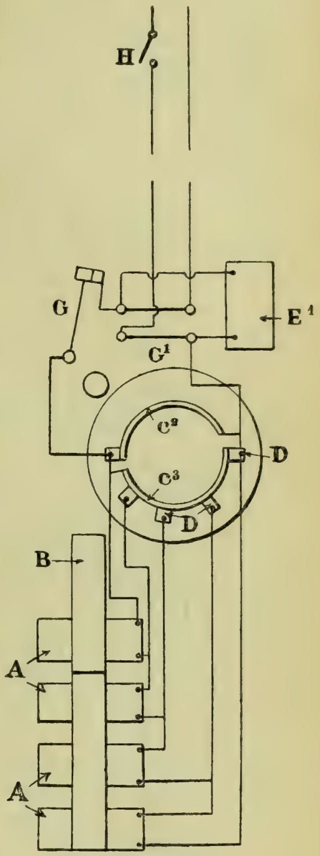


Fig. 8.

When this movement is completed, the end *f* of the locking lever drops into the slot c^6, which now faces it. The switch G is thus abruptly opened, cutting the circuit in the operating electro-magnet A, while the circuit is still maintained in the line which controls this signal, and consequently in the "retaining" electro-magnet E^1. Hence the latter still upholds the armature E, though the latter is no longer upheld by the scroll cam c^4, which together with the plate C has altered its position.

To bring the signal back to " danger ", it suffices to break the circuit. As soon as this is done, the electro-magnet E^1 ceases to attract the armature, which descends with its full weight, causing the projection e^2, arranged on its extension, to act by percussion upon the part f^1 of lever F, which it dislodges from the slot and thus releases the pulley, and consequently, the signal.

The locking thus mechanically obtained by the bolt f going into an intercepting slot c^6 affords absolute security, quite independent of the magnetic retention of the armature E; consequently, any efforts made improperly to bring the signal back to " danger ", would not have the effect of dislodging this armature, however weak the magnetic attraction.

Notwithstanding this absolute retention and this complete independence, the return of the signal to " danger " is positively insured the very instant the circuit is broken either normally or by accident, owing to the weight of the part E, and to the percussion produced by its fall upon the projection f^1 of the " locking lever " F.

While the signal is being brought back to " danger ", the cam c^4 has relifted the part E, which is in readiness to be held fast by the attraction of the electro-magnet as soon as the circuit is closed for the next signalling operation.

b) ELECTRIC APPARATUS FOR WORKING SWITCHPOINTS BY ELECTRICITY.

The switch-working apparatus is double-acting.

It comprises (figs. 9 to 13) :

1° A " sectional " electro-magnet A and a bi-conical core B which by means of a cross-piece C, sets in motion a slide D;

2° A slide D, on a cast-iron base, and guided laterally by two rollers e^1 and e^2. This slide is provided with a slope R both sides of which terminate parallel to the track;

3° A frame G, connected by means of the rod T with the movable system consisting of the core and the " carriage ". This frame carries the contact-piece which will successively close the circuit on the first " galette " excited in the direction of the motion of the appliance by means of a " quick-break " arrangement if necessary. This latter is so arranged that sparking by self-induction is almost entirely obviated (figs. 12 and 13);

4° A bar P, vertical to the whole apparatus, to which the slope R imparts a reciprocating motion by means of the two rollers p^1 and p^2, according to the direction in which the slide D travels. This bar is attached to the switch mechanism, the working of which it ensures. In the terminal positions, the two rollers, being retained by the straight parts of the slide, ensure *absolute* " *locking* " of the switch-point.

The working of the system is very simple; all that is required is to close the circuit on the wire 1 or G (*see* diagram, fig. 8) in order to cause the electro-magnetic device to move in the direction of the arrow. If, on the other hand, the circuit is closed on the wire 2 or D, the motor will move in the opposite direction.

This motion can be arrested, and restarted in either direction, at any point of the stroke.

An abrupt stoppage has no dangerous effects; it does not cause any " blowing out " of fuses, and consequently the accidents which might be caused by finally breaking the circuit, are avoided.

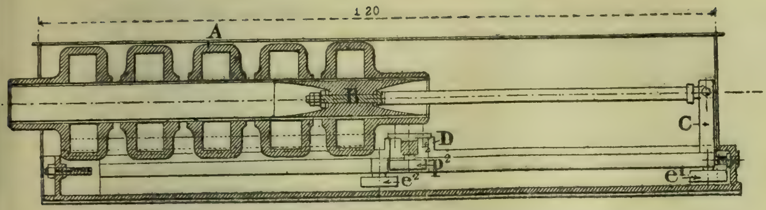


Fig. 9. — Elevation. — Section through AB.

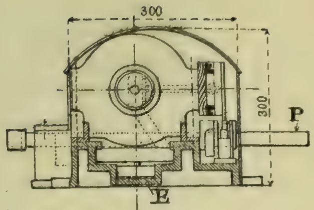


Fig. 10. — Lateral elevation. Section through CD.

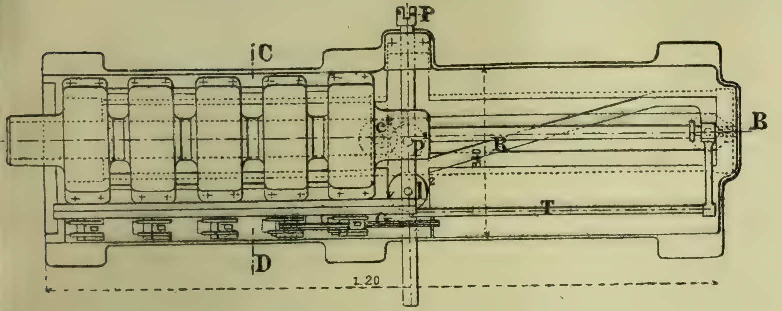


Fig. 11. — Plan.

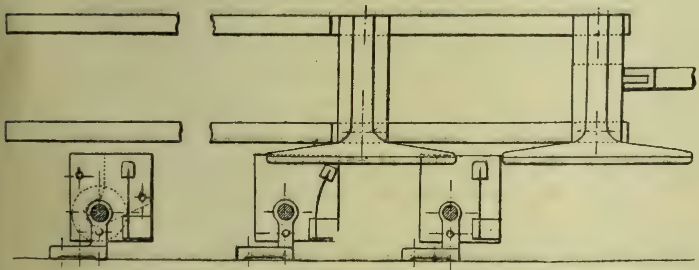


Fig. 12. — Elevation.

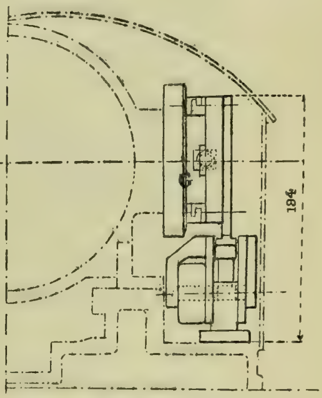


Fig. 13. — Lateral elevation.

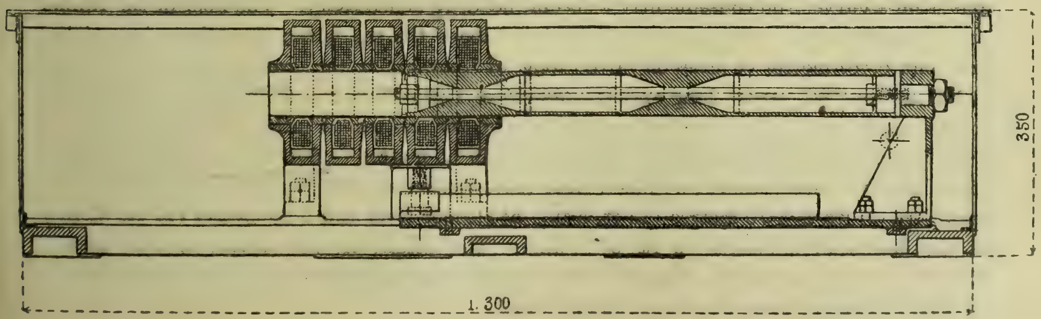


Fig. 14.

The shifting of the switch-point is effected without any jerk, and the toe of the switch is brought up against the stockrail without any shock or violence.

A different arrangement of the apparatus, which has likewise given satisfactory results, is shown in figure 14.

In this modification, the number of " galettes " is reduced by half, but there are two cores, which are successsively attracted towards these coils. The current-switching arrangement is consequently modified, and the current, after having excited the last coil, returns towards the first, which then attracts the second core, and so on. By multiplying the number of cores, the stroke could be doubled or trebled.

With these arrangements, high voltage currents (500 volts) could be used.

[625 .1 (.494)]

4. — The Bernese Alps Railway.

(*Schweizerische Bauzeitung.*)

The first quarterly report on the construction of the Bernese Alps Railway (Frutigen-Brigue), dated December 31, 1906, has just reached us. We extract the main particulars for the information of our readers :

" On August 15, 1906, the contract for the construction of the railway was signed by the Paris *Entreprise générale de construction*, consisting of Messrs F. Allard, L. Chagnaud, L. Coiseau, A. Couvreux, J. Dollfuss, A. Duparchy and L. Wiriot. The contract specifies that the Lötschberg tunnel is to be completed in four and a half years, reckoned from the time the piercing is commenced, for the sum of 37 million francs (£1,480,000), in which 7 millions of francs (£280,000) are included for the installations necessary. The piercing has to begun not later than five months after the land for the installations and the line has been placed at the disposal of the contractors. The deeds of the transfer of the land and of the triangulation (*i. e.* specifying the centre line of the tunnel) were signed on October 1, 1906; consequently the tunnel has to be finished and handed over by September 1, 1911.

" The length of the tunnel between the two ends specified in the contract is 13,735 metres (8 miles 941 yards) ; it starts in a straight line from Kandersteg towards Goppenstein, and passes under the Schafberg, the Gasterntal and the Lötschenpass. On the south side the exit is on a curve, and consequently a special heading is necessary. The floor of the tunnel at the north exit is 1,200 metres (3,937 feet) above the sea level ; then there is a rising gradient, 6,467 metres (4 miles 33 yards) long, of 7 per mil, to the level passing place, which is 500 metres (547 yards) long and at a height of 1,245·27 metres (4,086 feet). From this to the south exit, there is a falling gradient, 6,768 metres (4 miles 362 yards) long, of 3·8 per mil ; the south exit is at a height of 1,219·55 metres (4,001 feet). The Lötschberg tunnel takes a single track, and has a clear cross-section of 24·25 square metres (261 square feet) ; the width is 4·70 metres (15 ft. 5 in.) at sleeper-level and 5·20 metres (17 ft. $^3/_4$ in.) at the height of 2 metres (6 ft. 6 $^3/_4$ in.). The height in the middle is 5·50 metres (18 ft. $^9/_{16}$ in.) above the sleeper-level. At the passing place, the cross-section will be enlarged so as to accommodate a double track.

“The installations on the north side are located between the high road,. the railway and the foot of the Schafberg, and occupy an area of 16 hectares (39·5 acres). At Goppenstein, an area of 6·1 hectares (15 acres) is provided for the installations; it is situated, at some little distance from the tunnel exit, between the railway and Lonza. The Kander and Hagneck power stations have jointly contracted to supply the power required for constructing the tunnel. On the north side, the power is supplied from Spiez, where a new generating station will be erected near Bunderbach on the left bank of the Kander river; the pressure of the current transmitted to the transformers at the installation will be 15,000 volts. On the south side, the Upper Lonza power station will supply the current, on account of the Kander and Hagneck stations.

“As regards the tunnel work proper, the report informs us that the north heading has a clear width of 2·8 metres (9 ft. 2 $^1/_4$ in.) and a clear height of 2·6 metres (8 ft. 6 $^3/_8$ in.), so that it has a cross-section of 7·3 square metres (78·6 square feet). The south heading has a cross-section of 6·2 square metres (66·7 square feet) in the detritus and of 6·1 square metres (65·7 square feet) in the rock. As regards the progress of the work and the geological conditions encountered, we refer our readers to the reports which are published regularly every month.

“The triangulation of the centre line of the tunnel was completed on September 29, 1906. Starting from the points on the centre line fixed at each end of the tunnels, a direct line was set out over the mountain; the mean of eight determinations showed that the deviation, on the Wildelsigengrat, was 25 millimetres (1 inch). As this error is of no importance as far as the work of the first few months is concerned, the correction of the bench-marks of the principal stations will not be undertaken till summer 1907. The heights above sea level were determined from the bench-marks of the federal survey; the federal survey moreover carried a fresh set of levels from Gampel to Goppenstein.

“The survey work for the two approaches is completed; the plans of the curves are now being marked out.”

[385 .581.1]

5. — Days of rest on the Paris-Lyons-Mediterranean Railway.

(*Journal des Transports.*)

The Paris-Lyons-Mediterranean Railway Company, on March 15, 1907, issued the following instructions for applying the new system of days of rest in its service.

Rests and leave of the employees.

The company has decided that all of its employees are instead of the weekly holiday which is impracticable in the railway service, to have fifty-two days off duty each year.

The present order which applies to all the different departments of the company, lays down the general principles which shall guide the heads of the different departments in deciding the individual cases as they arise.

Employees whose rests are specified in the ministerial orders.

1. — To the regulation rests specified in the ministerial orders (¹) there shall be added. as may be required, extra rests given, according to the needs of the service, either as whole days, or on Sundays as half-days (²), so that every employee shall have each month at least three days of rest at home, each extra long rest being counted as one day (³).

The total number of days off shall be made up to the fifty-two days of rest per year as may suit the wishes of the employees and the needs of the service.

Of the employees who are alternately on day duty and on night duty, those with whom the alternations are every seven or eight days, shall have an extra rest of twenty-four hours to every two unbroken periods of seven or eight nights each.

The annual leaves granted in general order No. 4 shall be included in the days of rest as specified above.

Employees whose rests are not specified in the ministerial orders.

2. — Etablishments generally closed on Sunday and feast days.

The employees at the central or district offices, the stores, the workshops (other than those attached to locomotive sheds), as a rule already have Sundays and feast days off. Therefore nothing particular is specified in their case.

In the case of those who are required to work part of Sunday or the whole of it, either in order to maintain the continuity of tfe service or in case of specially urgent work, there shall be given extra rests, as may be required, so that they shall have fifty-two days off per year, the leaves granted in general order No. 4 included.

3. — Establishments generally open on Sundays and feast days.

There shall be at least three days of rest per month, either as whole days or on Sundays as half days, as the service may require.

The total number of days off shall be made up to the fifty-two days of rest per year, as may suit the wishes of the employees and the needs of the service.

Of the employees who alternately on day duty and on night duty, those with whom the alternations are every seven or eight days, shall have an extra rest of twenty-four hours to every two unbroken periods of seven or eight nights each.

The annual leaves granted in general order No. 4 sholl be included in the days of rest as specified above.

General regulations.

4. — The measures specified above shall apply to all employees paid by the year or by the month.

(¹) November 4, 1899, May 20, 1902 and May 9, 1906 for drivers, firemen and the train staff; November 23, 1899 for the station staff; October 10, 1901 for the permanent way staff.

(²) Half-day rests can be given on days other than Sundays to employees who desire this to be done.

(³) If for some exceptional reason the number of rests at home is reduced to two, in any given month, the rest which the employee has lost is to be made up during the first fortnight of the next month.

The employees paid by the day's work shall also have fifty-two days off per year; as before, no pay will be given on these days off, the rate of the daily wage being fixed accordingly.

5. — The extra rests shall as far as possible not be given during the busiest times.

The year for these purposes shall be reckoned from April 1 to March 31.

6. — These measures shall not apply to the higher officials, whose rests, even if their work affects questions of safety, are not considered as regulated by the ministerial orders.

The measures specified in this present service order shall begin to be applied on April 1, and shall come into full force within three months of that date.

[385. (09.2]

OBITUARY

Dr von OESTERLEN,

Administrative chief of the royal general directorate of the Wurtemberg State Railways,
Member of the Permanent Commission of the International Railway Congress Association.

But a few months after his election as member of the Permanent Commission of the Congress, we have to mourn the loss of Dr von Oesterlen, the eminent administrative chief of the general directorate of the Wurtemberg railways.

There follow a few biographical notes that we have been able to secure as to his life :

He was born at Stuttgart in 1860, the son of an advocate in that city.

From the autumn of 1878 to the spring of 1882 (seven half years) he took courses at Tubingue, Leipsic, Munich and Berlin universities.

In the spring of 1882, he passed his first and in the autumn of 1885 his second honours examinations for admission to the judicial magistracy.

In 1886, he was appointed assistant district judge attached to the courts of the Heidenheim canton and the city of Stuttgart; then successively he became canton judge at Geislingen, assistant judge to the Ravensburg district court, and to the Stuttgart district court.

In 1893, he was appointed assistant college collaborator to the general directorate of the Wurtemberg railways, and then successively rose to be legal member of college, with rank of finance assessor and finance counsellor.

In 1899, he was delegated to the Wurtemberg foreign office department, in the commercial relations' branch, to fulfil the duties of arbitrator; he was next appointed ministerial counsellor, next member of the council of ways and communications, head of the ministerial chancellery, and finally in 1905, controller and chief of the administrative section of the general directorate of the State railways.

He died on April 25, 1907. His decorations included the cross of honour of the Crown of Wurtemberg, the cross of knight of the 1st class of the order of Frederick, the order of the Red Eagle of Prussia of the 3rd class, the cross of commander of the order of the Crown of Bavaria, and the cross of officer of the order of St. Maurice and St. Lazarus.

The deceased had since 1905 been president of the Committee of the German railway Union (*Verein*) for business connected with the passenger service and he had succeeded, in this difficult position, in gaining the regard and sympathy of everybody.

The Committee of Management.

NEW BOOKS AND PUBLICATIONS

[621 .13 & 385. (04]

GARBE (Robert), Member of the Board of Works, Member of the Berlin Directorate of the Royal Prussian Railways. — **Die Dampflokomotiven der Gegenwart (Steam locomotives of to-day).** — One volume octavo (27·5 × 20 centimetres [10 $^{13}/_{16}$ × 8 inches]), xvi + 500 pages with 388 figures and 4 plates in the text, 2 tables and 20 plates separately. — 1907, Berlin, Julius Springer, editor. Price : 24 Marks (£1.4*s*.).

For a long time, locomotive construction in Germany was carried out on the old, customary lines; it is true that the boiler was made larger, the engine was made stronger, the pressure was increased, and details were improved, but no new principle of any importance was involved. In course of time, however, it became apparent that the continually growing demands of the traffic would not be satisfied, in the long run, by simply increasing the dimensions, and this observation gave a new stimulus to the study of the locomotive; moreover, the evolution of electric traction contributed to stimulate engineers and designers. During the last ten or fifteen years, more new types have been brought out than during the preceding twenty or thirty years. The question of improving the power and the economy of the locomotive by a better utilization of the steam was the first thing considered; in this direction very favourable results were obtained by compounding and by the use of superheated steam. Two of our most eminent colleagues, Messrs. von Borries and R. Garbe, largely contributed to the introduction of these new principles in Germany, and did much work in investigating and improving locomotives of these types. Mr. Garbe, in the work here reviewed, gives the results of his long experience in building and running locomotives, more especially as regards locomotives using superheated steam.

The book consists of two parts; the first chiefly contains a description and critical examination of the newest and most powerful locomotives built in America, which the author studied during his travels in that country. He then adds a description of some of the new four-cylinder compounds built during the last few years in England, France, Germany and Italy. Although the construction of most of these locomotives has already been described in the technical publications, the chapters devoted to this subject in Mr. Garbe's book are of very great interest, as the dimensions and performances of the locomotives are well tabulated and critical remarks are added on the different types and on the results obtained. The position the author takes is already clearly shown in this part of the book : he believes that the locomotive using superheated steam, with the Schmidt superheater, is the most powerful, the most simple and the most economical engine; and the other types, more especially the compounds, are condemned with the decision characteristic of the author.

Another chapter of the first part deals with the design of the different details of modern locomotives : boiler, fire-box, bar frame, cylinders, piston valves, etc. Valuable information is given on the theoretical and practical utility of certain types; the dicta of eminent authorities are in some cases reproduced verbally. Thus it is shown that the wide fire-boxes, much used in Germany, have in America not given as good results as long, narrow and deep fire-boxes; and that the well known bar frames have shown deficiencies, so that even in America plate frames are now preferred for heavy locomotives.

The first part is concluded by a consideration of American locomotive construction generally. The author relates his experiences and observations on the relations between the railways and the locomotive builders, on the professional instruction and the organization of the different employees, on the organization and operation of loco shops. These explanations give a good picture of conditions in the United States, which differ largely in many respects from those which prevail in Germany. The American Locomotive Company, which was founded in New York in 1901, has absorbed all the larger locomotive works in the United States, except the Baldwin Works at Philadelphia; it can supply 5,000 locomotives per year. This vast centralization of locomotive building opposes to the railway companies a formidable monopoly, to which the German combination of locomotive builders is certainly to be preferred. The author concludes that as regards the simple and suitable machining of the various details, and as regards the construction of locomotives as a whole, German manufacturers are at least on the same level as American. The importance of the locomotive industry in the United States is shown by the fact that 5,491 locomotives were built in 1905; of these 140 were electric locomotives and 177 compounds. Only 515 were exported. In 1906, more than 6,000 locomotives were built.

The second and larger part of the book is devoted to the locomotives using superheated steam, and commences with a short theoretical examination of superheated steam and its properties. It has been found that strongly superheated steam does not conduct heat so well as saturated steam; this property, which is very valuable as regards the use of such steam, is on the other hand an obstacle to its generation. The true efficiency of superheating has not yet been exactly determined. The specific heat of superheated steam has been measured, only quite recently, in a series of experiments made at the Munich Technical High School (1). They show that the mean specific heat of steam, under a pressure of 12 kilograms per square centimetre (170·67 lb. per square inch) and at a temperature of 350° C. (662° Fahr.), is 0·529. Mr. Garbe in his calculations assumes a figure 15 per cent higher, namely 0·6. In the same chapter, the important economies in fuel and water, and the increase in power of locomotives using superheated steam, as compared with other types, is theoretically explained and evidenced by the results obtained in actual trials.

In the next chapter, the locomotive using superheated steam is compared with the four-cylinder compound, and the author examines the advantages and the disadvantages of the two systems. The former is reproached with excessive initial pressure in the cylinders, and want of smoothness in running; and in this connection, the author proceeds to a complete theoretical investigation into the causes of the oscillations and irregular movements of locomotives. Although in the new 4-4-0 locomotives using superheated steam, the reciprocating masses are not balanced, yet (the author states) they run smoothly. In this case, it is the very stiff coupling to the tender which must have a peculiarly favourable influence, as the other conditions are hardly more favourable in locomotives using superheated steam than in compounds. When the locomotive using superheated steam runs with regulator closed, compression in the cylinders is avoided by means of a passage between the two ends of the cylinder, which is opened when the regulator is closed. Excessive initial pressure in the cylinders cannot be avoided, and at first gave rise to considerable trouble. It became necessary to strengthen the crank pins, the bearings, and sundry details; moreover specially careful lubrication is necessary. The disadvantages of compounds, according to the author, are the great weight and the comparatively small increase in the power. Mr. Garbe is of opinion, as already stated, that the four-cylinder compound is a bad type, and that even the lately attempted superheating of the steam in the intermediate receiver, cannot produce a material improvement. We are at present unable to share this opinion. At the 1905 Liége exhibition, the Seraing works exhibited a four-cylinder compound in which either the high and the low pressure steam can be superheated, or only the low pressure steam. The results of the trials will certainly give interesting information as to the best application of superheat. As to the question, whether superheating alone suffices under all conditions and is superior to superheating and compounding jointly, expert opinions widely diverge. While Mr. von Borries, as a result of his experience, maintains that the four-cylinder compound using superheated steam will best satisfy all future requirements, Mr. Garbe pronounces in favour of greater simplicity in construction, and asserts that the non-compound using superheated steam will be the locomotive of the future. Time will show which of these two views is the more correct. Two-cylinder locomotives will not always suffice for high-speed trains and special performances generally; the author himself recognizes that in such cases, four-cylinder locomotives may become necessary, and he gives a very good design for a locomotive of this type. But when a locomotive has four cylinders, it seems natural to add compounding to the superheating. In any case, locomotives using superheated steam, whether compounds or non-compounds, have a large future before them.

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(1) See *Zeitschrift des Vereines deutscher Ingenieure*, 1907, No. 4.

Special chapters are then devoted to the different varieties of superheaters, and the peculiarities of non-compound locomotives using superheated steam are considered. According to the experience of the author, the Schmidt smoke tube superheater best satisfies existing requirements; it enables the steam to be superheated up to 360° C. (680° Fahr.). The trials made have shown that considerable benefit is only to be obtained by using strongly superheated steam, whereas a feeble effect is produced on the power and consumption if steam is used having a temperature of 250° C. (482° Fahr.) or less.

In chapter V, details are given of trials made with locomotives using superheated steam. The next chapter contains a description of the new Prussian State Railway locomotives which use superheated steam. In this case again, the author recommends the limitation of the number of types, the simplification of the construction and the standardization of the separate parts; he feels convinced that considerable advantages will result both in use and in construction.

The final chapter of the book contains sundry information. In the first place several locomotives, using superheated steam, which were exhibited in Milan and in Nuremberg in 1906, are considered from the author's point of view. Then comes a note on the admissible limits of the speed of express trains. In the earlier part of the work already the author predicts that in the future also mean running speeds of 100 kilometres (62 miles) per hour, with occasional maximums of from 120 to 130 kilometres (74·5 to 81 miles) per hour, will be the limit realizable for the chief expresses. As long as only steam locomotives are in question, this opinion may be a justifiable one; but if the possibility of greater speeds generally is denied, either on grounds of danger or of excessive cost, we cannot agree, as electric locomotives can run at higher speeds with safety and certainty. It is probable that trains will be quicker in the future than they are at present, and this is recognized in the new German regulations (Eisenbahn-Bau und Betriebsordnung für die Eisenbahnen Deutschlands), in which no upper limit for speed is specified. Now this omission in the regulations is due, not as the author thinks, only to the high speed trials run by steam locomotives, but no doubt chiefly to the trials of electric locomotives. It is always risky to prophesy in railway matters; many mistakes have already been recorded.

Finally, a summary is given of all the deductions drawn from the information contained in the book, in the form of sixty-one conclusions.

We are unable, in this short criticism, to give particulars of all the contents of this very well-written book; yet it may give an idea of the richness and variety of the information set forth.

The use of superheated steam has made considerable progress, in spite of all the difficulties encountered; and it is chiefly due to the great energy and diligence of the author that the construction of locomotives using superheated steam has advanced to the point that at present many are in use, hauling trains punctually and with good results economically. Mr. Garbe's work forms a solid foundation for the future development of locomotives using superheated steam. The book contains many important observations and new ideas of great value to all railway men and especially to locomotive engineers; nor will it fail generally to stimulate interest in the use of superheated steam for locomotives. It is got up in good style and the careful and clear way in which the figures and the lithographed plates are executed is worthy of praise.

(*Annalen für Gewerbe und Bauwesen.*) LOCHNER.

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I. — BIBLIOGRAPHY OF BOOKS

(July, 1907.)

In French.

1907 **625** .7 (02

DE BAUVE (A.), inspecteur géneral des ponts et chaussées, professeur à l'école nationale des ponts et chaussées.

Construction et entretien des routes et chemins.

Paris, H. Dunod & E. Pinat, éditeurs. Deuxième édition, in-8°, 480 pages, 187 figures, 2 planches. (Prix : 18 francs.)

1907 **621** .33

GRAFFIGNY (H. de).

La locomotion électrique. (Histoire de la locomotion électrique, traction électrique par accumulateurs, les électromobiles, les tramways à trolley aérien, les tramways à canalisation souterraine et au niveau du sol, les chemins de fer à traction électrique, etc.)

Mayenne, imprimerie Colin ; Paris, librairie des publications populaires. In-8°, 200 pages, 25 figures explicatives.

1907 **721** .9 (02

KERSTEN (C.), ingénieur, architecte, professeur à l'école royale de travaux publics de Berlin.

La construction en béton armé. Guide théorique et pratique. Traduit d'après la troisième édition allemande par P. Poinsignon, ingénieur E. C. L. — 1re partie : Calcul et exécution des formes élémentaires.

Paris, Gauthier-Villars. In-8°, 199 pages avec figures. (Prix : 6 francs.)

1907 **625** .6 (01

PAYEN (Fernand), docteur en droit, avocat à la Cour d'appel.

Des concessions de chemins de fer d'intérêt local et de tramways.

Paris, Arthur Rousseau, éditeur. 1 volume in-8°, VIII-508 pages. (Prix : 10 francs.)

1907 **385** .15

PRICE (Georges).

Le rachat des chemins de fer. Examen des intérêts des compagnies, du public, des finances de l'État.

Paris, H. Dunod & E. Pinat, éditeurs. In-8°, 114 pages. (Prix : 2.50 francs.)

1907 **721**

VIERENDEEL (A.), professeur à l'université de Louvain.

Cours de stabilité des constructions. Tome VI : Maçonneries, fondations, béton armé.

Paris, H. Dunod & E. Pinat, éditeurs. In-8°, 300 pages, 152 figures, 18 planches. (Prix : 16 francs.)

In German.

1907 **721** .9

BARKHAUSEN (G.), Prof., Geheim. Reg.-Rat.

Theorie der Verbundbauten in Eisenbeton.

Wiesbaden, C. W. Kreidels Verlag. In-4°, 26 Seiten, 17 Abbildungen. (Preis : 2 Mark.)

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(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels. (See "Bibliographical Decimal Classification as applied to Railway Science," by L. Weissenbruch, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

N. B. — The Monthly Bibliography is printed on one side only so that it may be cut up into slips and pasted on labels for catalogues and indexes.

1907 **669.** (01
BAUMANN (R.), Ingen. Priv. Doz.
Die Festigkeitseigenschaften der Metalle in Wärme und Kälte.
Stuttgart, A. Kröner. In-8°, III-72 Seiten mit 46 Abbildungen. (Preis : 3 Mark.)

1907 **721** .9 (01
BULNHEIM (Max), Baumeister.
Grundsätze für statische Berechnungen, Ausführung von Eisenbetonbauten und Verwendung von Ersatzbaustoffen.
Dresden, C. Heinrich. (Preis : 5 Mark.)

1907 **621** .1 (02
DUBBEL (Heinr.), Ingen.
Entwerfen und Berechnen der Dampfmaschinen. Ein Lehr- und Handbuch für Studierende und angeh. Konstrukteure.
Berlin, J. Springer. 2. Auflage, in-8°, XII-452 Seiten mit 127 Figuren. (Preis : 10 Mark.)

1907 **721** .9
NOWAK (A.), Ingenieur, Baukommissär der k. k. Eisenbahnbaudirektion in Wien.
Der Eisenbetonbau bei den neuen von der k. k. Eisenbahnbaudirektion ausgeführten Bahnlinien Oesterreichs.
Berlin, Wilhelm Ernst & Sohn. In-8°, 88 Seiten, 81 Textabbildungen und 6 Tafeln. (Preis : 4 Mark.)

1906 **721** .9 (01
PELGRIM (Heinr.), Ingenieur.
Theoretische Berechnung der Betoneisen-Konstruktionen mit ausführlichen Beispielen.
Wiesbaden, C. W. Kreidels Verlag. In-4°, 46 Seiten mit 78 Abbildungen. Preis : 2.80 Mark.)

1906 **625** .255
RÜDENBERG (R.), Dr. Ing.
Energie der Wirbelströme in elektrischen Bremsen und Dynamomaschinen.
Stuttgart, Ferdinand Enke. 102 Seiten, 21 Figuren. (Preis : 3.60 Mark.)

1907 **621** .137.1 (02
STOCKERT (Ludw. Ritter v.), Prof. Ing.
Die Lokomotive. Ein Lehrbuch für Lokomotivführer und Führerlehrlinge.
Wien, K. Graeser & Co. In-8°, VI-170 Seiten mit Abbildungen. (Preis : 6 Mark.)

In English.

1907 **625** .13
FOX (Francis), M. Inst. C. E.
The Simplon tunnel.
London, Institution of Civil Engineers.

1907 **694.** (02
HASLUCK (Paul Noncree).
Cassell's carpentry and joinery; comprising notes on materials, processes, principles, and practice.
Philadelphia, David McKay. O., 567 pages, 1,800 engravings, 12 pl. (Price : $3.)

1907 **656** .2
MACPHERSON (L. G.).
The working of the railroad.
London, Bell. 8vo. (Price : 6*s.*)

1907 **621** .3 (02
MUNRO (J.) & **JAMIESON** (A.).
A pocket-book of electrical rules and tables for the use of electricians and engineers.
London, Griffin. Oblong. 18mo. (Price : 8*s.* 6*d.*)

1907 **62.** (02
NUGENT (Paul Cook).
Plane surveying : a text and reference book for the use of students in engineering and for engineers generally.
New York, John Wiley & Sons. Second edition, 8vo, 20 + 583 pages, il. pls, map, plans, diagrams, tables. (Price : $3.50.)

1907 **385.** 15
PRATT (Edwin A.).
State railways.
London, P. S. King & Son. (8 1/4 × 5 1/2 × 1/2 inches), 107 pages. (Price : 1*s.*

1907 **62.** (02
RANKINE (W. J. M.).
A manual of civil engineering. Twenty-third edition, revised by W. J. MILLAR.
London, Griffin. 8vo, (8 × 5 1/4 inches), 838 pages. (Price : 16*s.*)

1907 **691**
SABIN (L. Carlton).
Cement and concrete.
New York, McGraw Publishing Co. Second edition, 8vo, 11 + 572 pages, diagrams, tables. (Price : $5.)

1907 **62.** (03
Spon's dictionary of engineering. Special edition, with supplement.
New York, Spon & Chamberlain. 8vo. (Price : $37.50.)

1907 **385** .1
The Earning power of railroads.
New York, Floyd W. Mundy, of Jas. H. Olyphant & Co. (7 × 4 3/4 inches), 337 pages.

907 **697**. (02

THOMPSON (C. Bedford).

Heating by steam and water: a practical treatise on house eating; improved methods of installing heating apparatus the home, etc.

New York, Plumbers' Trade Journal Publishing Co. 4to, 265 pages, 268 original drawings. (Price : $3.)

In Italian.

1907 **721** .9

GUIDI (C.), prof.

Le costruzioni in béton armato.

Torino, tip. Bona. Seconda edizione, 120 pagine con 55 figure nel testo e 8 tavole.

II. — BIBLIOGRAPHY OF PERIODICALS

(June, 1907.)

In French.

Annales des mines. (Paris.)

1907 **385** .3 (.73)
Annales des mines, mars, p. 276.

HENRY-GRÉARD (O.). — Note sur les réformes récentes de la législation fédérale des chemins de fer aux États-Unis. (6,800 mots.)

Annales des ponts et chaussées. (Paris.)

1907 **313** .385 (.942)
Annales des ponts et chaussées, II, p. 356.

Résultats généraux de l'exploitation des chemins de fer de l'Australie méridionale pendant les exercices 1903-1904 et 1904-1905. (6 tableaux.)

1907 **313** .385 (.498)
Annales des ponts et chaussées, II, p. 358.

Résultats généraux de l'exploitation des chemins de fer de l'État roumain pendant les années 1903 et 1904. (5 tableaux.)

1907 **385** .113 (.496)
Annales des ponts et chaussées, II, p. 360.

Recettes des compagnies de chemins de fer ottomans en 1905. (4 tableaux.)

Annales des travaux publics de Belgique. (Bruxelles.)

1907 **697**. (01
Annales des travaux publics de Belgique, juin, p. 341.

MATHIEU (E.). — Calcul des installations de chauffage par l'eau chaude à basse pression. (24,000 mots, tableaux & fig.)

Bulletin de l'Association du Congrès international des chemins de fer. (Bruxelles.)

1907 **621** .134.3
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 557.

GOSS (W. F. M.). — Les hautes pressions de vapeur dans le service des locomotives. (4,200 mots, 2 tableaux & fig.)

1907 **656** .222.1 (.431 + .73)
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 566.

SCHULZE (W. A.). — La vitesse des trains sur les chemins de fer américains et allemands. (4,200 mots.)

1907 **621** .138.2
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 573.

GUILLERY (C.). — Le parc à charbon de la gare de Cologne (Eifeltor). (2,200 mots & fig.)

1907 **669**
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 580.

SUGGATE (Alfred). — Alliages pour coussinets. (6,400 mots, 2 tableaux & fig.)

1907 **656** .253
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 595.

Nouveau signal répétiteur placé sur la locomotive (Driver's Cab Signal). (3,900 mots & fig.)

1907 **625** .253
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 608.

Le frein à air comprimé Chapsal-Saillot. (1,300 mots & fig.)

1907 **625** .61 (09.1 (.54)
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 613.

Le chemin de fer économique de Barsi. (3,600 mots & fig.)

1907 **621** .132.5 & **621** .134.3
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 621.

Locomotive à surchauffeur construite par les ateliers Baldwin pour le « Pittsburg, Shawmut & Northern Railway ». (750 mots & fig.)

1907 **625** .253
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 625.

La triple valve M. (1,500 mots & fig.)

1907 **621** .134.3
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 629.

Les progrès de la surchauffe. (1,400 mots.)

1907 **656** .222.1
Bulletin du Congrès des chemins de fer, n° 6, juin, p. 631.

Les dangers de la vitesse. (1,650 mots.)

1907 **621** .33 (.42)
lletin du Congrès des chemins de fer, nº 6, juin, p. 634.

Le « Metropolitan District Railway ». (2,100 mots.)

1907 **621** .33 (.45)
lletin du Congrès des chemins de fer, nº 6, juin, p. 638.

Électrification de chemins de fer italiens. (100 mots.)

1907 **385** .581 (.73)
lletin du Congrès des chemins de fer, nº 6, juin, p. 638.

La limitation des heures de service des employés des emins de fer aux États-Unis. (900 mots.)

1907 **625** .1 (.494)
lletin du Congrès des chemins de fer, nº 6, juin, p. 640.

Le chemin de fer des Alpes bernoises. (800 mots.)

1907 **016** .385. (02
lletin du Congrès des chemins de fer, nº 6, juin, p. 75.

Bibliographie mensuelle des chemins de fer. — Livres.
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Bibliographie mensuelle des chemins de fer. — Pério-
ues. (166 fiches.)

Bulletin de la Société d'encouragement pour l'industrie nationale. (Paris.)

907 **625** .7
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ESPITALLIER (G.). — Le sol de nos routes et de nos
es. (6,000 mots & fig.)

Génie civil. (Paris.)

907 **624** .52
nie civil, nº 1303, 1er juin, p. 72.

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0 mots & fig.)

907 **625** .216
ie civil, nº 1304, 8 juin, p. 100.

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alis. (700 mots & fig.)

907 **621** .33 (.45)
ie civil, nº 1306, 22 juin, p. 121.

HIGNATERIE (P.). — Chemin de fer électrique
nophasé de la vallée du Brembo (Lombardie). (1,000
ts & fig.)

1907 **62**. (01 & **669**. (01
Génie civil, nº 1306, 22 juin, p. 123.

GUILLET (L.). — L'utilisation industrielle de la métallographie microscopique. (4,200 mots & fig.)

Journal des transports. (Paris.)

1907 **385** .113 (.44)
Journal des transports, nº 25, 22 juin, p. 289.

Les résultats de 1906. — Le Métropolitain de Paris. (1,800 mots & 3 tableaux.)

1907 **385** .113 (.44)
Journal des transports, nº 26, 29 juin, p. 301.

Les résultats de 1906. — Réseau de l'Est. (1,200 mots & 1 tableau.)

Nouvelles annales de la construction. (Paris.)

1907 **656** .211.7
Nouvelles annales de la construction, nº 630, juin, p. 89.

Pont à transbordeur de Runcorn (Angleterre). (2,200 mots & fig.)

Revue générale des chemins de fer et des tramways. (Paris.)

1907 **656** .257
Revue générale des chemins de fer, nº 6, juin, p. 319.

COSSMANN & DESPONS (E.). — La reconstruction de la gare de Valenciennes. (10,000 mots, tableaux & fig.)

1907 **621** .135. (01 & **625** .2 (01
Revue générale des chemins de fer, nº 6, juin, p. 367.

MARIÉ (G.). — Les oscillations du matériel dues au matériel lui-même et les grandes vitesses des chemins de fer. (15,000 mots & fig.)

1907 **313** : **656** .28 (.42)
Revue générale des chemins de fer, nº 6, juin, p. 398.

Résumé du rapport général du « Board of Trade » sur les accidents survenus en 1905 sur les chemins de fer du Royaume-Uni. (2,000 mots & 10 tableaux.)

1907 **656** .223.2
Revue générale des chemins de fer, nº 6, juin, p. 408.

Crise des transports sur les réseaux d'État austro-hongrois. (1,200 mots.)

1907 **385** .13 (.43)
Revue générale des chemins de fer, nº 6, juin, p. 410.

L'impôt sur les billets de voyageurs en Allemagne. (1,500 mots & 1 tableau.)

1907 **621** .32 & **625** .233

Revue générale des chemins de fer, nº 6, juin, p. 413.

Éclairage électrique des trains sur le Great Western Railway en Angleterre. (500 mots & fig.)

In German.

Annalen für Gewerbe und Bauwesen. (Berlin.)

1907 **625** .13

Annalen für Gewerbe und Bauwesen, Nr 719, 1. Juni, S. 225.

PRESSEL. — Der Bau des Simplontunnels. (4 000 Wörter & Abb.)

1907 **625** .23 (06.4 & **625** .24 (06.4

Annalen für Gewerbe und Bauwesen, Nr 719, 1. Juni, S. 235.

MESSERSCHMIDT. — Personen- und Güterwagen auf der Mailänder Ausstellung 1906. (2 500 Wörter.)

1907 **621** .13 (06.4

Annalen für Gewerbe und Bauwesen, Nr 719, 1. Juni, S. 238.

SCHWARZE. — Die Lokomotiven auf der Mailänder Ausstellung 1906. (2 600 Wörter, 1 Tabelle & Abb.)

1907 **621** .33

Annalen für Gewerbe und Bauwesen, Nr 720, 15. Juni, S. 257.

MÜHLMANN. — Elektrischer Betrieb auf Vollbahnstrecken mit starken Steigungen. (3 000 Wörter & Abb.)

1907 **621** .13 & **621** .132.8

Annalen für Gewerbe und Bauwesen, Nr 720, 15. Juni, S. 268.

SCHIMANEK (E.). — Motorwagen oder Lokomotive. (2 700 Wörter & 2 Tabellen.

Bulletin des internationalen Eisenbahn-Kongress-Verbandes. (Brüssel.)

1907 **625** .216

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 537.

HUBERTI (A.) & DOYEN (J.). — Reibungsvorrichtungen in den Zug- und Druckorganen der Eisenbahnwagen. (2 400 Wörter & Abb.)

1907 **621** .134.3

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 545.

GOSS (W. F. M.). — Hoher Dampfdruck im Lokomotivbetriebe. (3 600 Wörter, 2 Tabellen & Abb.)

1907 **625** .251

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 554.

FOWLER (Geo. L.). — Versuche mit der Sauvage-Luftbremse. (4 300 Wörter, 2 Tabellen & Abb.)

1907 **625** .233

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 568.

WEDLER. — Die Entwickelung der Personenwagen-Beleuchtung der preussisch-hessischen Staats-Eisenbahnen bis zum hängenden Gasglühlichte. (3 000 Wörter, 4 Tabellen & Abb.)

1907 **621** .138.2

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 580.

GUILLERY (C.). — Bekohlanlage mit Greifer auf dem Bahnhof Köln (Eifeltor). (1 900 Wörter & Abb.)

1907 **625** .11 (.494 + .45)

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 587.

Splügenbahn. (3 300 Wörter, 5 Tabellen & Abb.)

1907 **656** .254

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 599.

Drahtlose Telegraphie im Eisenbahnbetriebe. (450 Wörter.)

1907 **621** .132.8

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 600.

Ein deutscher Triebwagen. (900 Wörter & Abb.)

1907 **656** .283

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 602.

Die Ursachen der Eisenbahn Zusammenstösse. (2 000 Wörter & 2 Tabellen.)

1907 **313** .385 (.42)

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 608.

Die grossen englischen Eisenbahnen im Jahre 1906. (700 Wörter & 2 Tabellen.)

1907 **625** .1 (.494)

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 612.

Berner Alpenbahn. (650 Wörter.)

1907 **385**. (09.2

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 614.

Nachruf : Iwan Adadurow. (1 200 Wörter & Bildniss.)

1907 **621** .13 & **385**. (04

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 619.

Bücherschau : Die Dampflokomotiven der Gegenwart, von Robert Garbe. (2 200 Wörter.)

1907 **016** .385. (02

Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 75.

Monatliches Verzeichnis der Eisenbahnliteratur. — Bücher. (24 Zettel.)

1907 **016** .385. (05
Bulletin des Eisenbahn-Kongresses, Nr 6, Juni, S. 78.

Monatliches Verzeichnis der Eisenbahnliteratur. — Zeitschriften. (166 Zettel.)

Elektrische Bahnen und Betriebe. Zeitschrift für Verkehrs- und Transportwesen. (München.)

1907 **621** .33
Elektrische Bahnen u. Betriebe, Heft 16, 4. Juni, S. 305.

PFORR (P.). — Der elektrische Vollbahnbetrieb. (8 800 Wörter & Abb.)

1907 **621** .33
Elektrische Bahnen u. Betriebe, Heft 17, 14. Juni, S. 321.

GEYER. — Der erste elektrische Reversierstrassenantrieb. (3 000 Wörter & Abb.)

1907 **621** .33 (.485)
Elektrische Bahnen u. Betriebe, Heft 17, 14. Juni, S. 326.

DAHLANDER (R.). — Elektrischer Betrieb der Schwedischen Staatseisenbahnen. (1 000 Wörter & Abb.)

Œsterreichische Eisenbahn-Zeitung. (Wien.)

1907 **385** .517
Œsterreichische Eisenbahn-Zeitung, Nr 17, 1. Juni, S. 153.

STEIN (M.). — Der Einfluss der Verstaatlichung auf die Krankenversicherung der Bahnbeamten und die Krankenkassenorganisation. (1 200 Wörter.)

Schweizerische Bauzeitung. (Zürich.)

1907 **625** .111
Schweizerische Bauzeitung, Nr 23, 8. Juni, S. 280.
— — Nr 24, 15. — S. 289.

Die Bodensee-Toggenburgbahn. (4 200 Wörter & Abb.)

1907 **624** .63
Schweizerische Bauzeitung, Nr 25, 22. Juni, S. 307.

Eisenbahnbrücke in armierten Beton über die Rhone bei Chippis im Kanton Wallis. (1 800 Wörter, 2 Tabellen & Abb.)

Zeitschrift des österreichischen Ingenieur- und Architekten-Vereines. (Wien.)

1907 **625** .13
Zeit. des öst. Ingen.- und Archit.-Ver., Nr 22, 31. Mai, S. 410.

HROMATKA (F.). — Der Berner Alpendurchstich (Lötschbergbahn). (2 600 Wörter, 3 Tabellen & Abb.)

1907 **621** .95 & **625** .13
Zeit. des öst. Ingen.- und Archit.-Ver., Nr 23, 7. Juni, S. 421.

BRABBÉE (K.). — Die maschinellen Anlagen beim Baue des Tauerntunnels. (3 500 Wörter & Abb.)

Zeitschrift für Kleinbahnen. (Berlin.)

1907 **621** .33
Zeitschrift für Kleinbahnen, Heft 6, Juni, S. 393.

Die wirtschaftlichen und Sozialen Wirkungen der elektrischen Städtebahnen im Staate Ohio. (3 000 Wörter.)

1907 **621** .13 & **621** .33
Zeitschrift für Kleinbahnen, Heft 6, Juni, S. 398.

ŽEŽULA (F.). — Dampfbetrieb oder elektrischer Betrieb? (3 200 Wörter & Tabellen.)

Zeitschrift des Vereines deutscher Ingenieure. (Berlin.)

1907 **621** .114 & **621** .135.2
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LENZ (K.). — Die Schmierung schnellaufender Maschinen. (5 800 Wörter & Abb.)

1907 **621** .33
Zeitsch. des Vereines deutscher Ingen., Nr 25, 22. Juni, S. 965.

REICHEL (W.). — Die Einführung des elektrischen Zugbetriebes auf den Berliner Stadt-Ring- und Vorortbahnen. (5 000 Wörter, 2 Tabellen & Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1907 **656** .225
Zeitung des Vereins, Nr 41, 1. Juni, S. 657.

SPANDAU. — Die Stückgutbehandlung. (1 500 Wörter.)

1907 **656** .212.5
Zeitung des Vereins, Nr 43, 8. Juni, S. 691.

Der neue Rangierbahnhof Mannheim. (1 100 Wörter & Abb.)

1907 **656** .234
Zeitung des Vereins, Nr 44, 12. Juni, S. 701.

DRILLING. — Nochmals das vereinfachte Abfertigungsverfahren für Gepäck bis zu 25 kg. (1 800 Wörter.)

1907 **385** .113 (.4)
Zeitung des Vereins, Nr 46, 19. Juni, S. 733.
— — Nr 47, 22. — S. 745.

WOLFF. — Die Betriebsergebnisse deutscher und ausländischer Eisenbahnen im Jahre 1904. (2 400 Wörter & 10 Tabellen.)

1907 **656** .253
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SCHOLKMANN. — Das Ueberfahren der Halte-
rnale. (2 700 Wörter.)

Zentralblatt der Bauverwaltung. (Berlin.)

1907 **721** .9 (01
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Bestimmungen für die Ausführung von Konstruktionen
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In English

American Engineer and Railroad Journal. (New York)

1907 **385**. (07.1
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A rational apprentice system. (5,500 words, 2 tables
fig.)

1907 **621** .132.5
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Mallet compound freight locomotive. (1,000 words,
table & fig.)

1907 **621** .132.1 (.73)
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A tabular comparison of notable examples of recent
comotives. (4 tables.)

1907 **625** .235
merican Engineer & R. Journal, June, p. 232.

All steel passenger service cars. (2,600 words & fig.)

American Machinist. (New York.)

1907 **625** .245
merican Machinist, No. 22, June 15, p. 757.

EMERY Jr. (A. H.). — A new railway car dynamo-
eter. (3,500 words & fig.)

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ulletin of the International Railway Congress Association. (Brussels.)

1907 **625** .216
ulletin of the Railway Congress, No. 6, June, p. 587.

HUBERTI (A.) & DOYEN (J.). — Friction gear for
ailway couplings. (2,500 words & fig.)

1907 **656** .212
Bulletin of the Railway Congress, No. 6, June, p. 595.

NORTH (H. M.). — The theory of the design of railway freight terminals. (11,400 words, 1 table & fig.)

1907 **656** .253
Bulletin of the Railway Congress, No. 6, June, p. 619.

The driver's cab signal. (3,600 words & fig.)

1907 **621** .33
Bulletin of the Railway Congress, No. 6, June, p. 632.

The London & North Western Electric Railway. (2,000 words & fig.)

1907 **621** .31
Bulletin of the Railway Congress, No. 6, June, p. 639.

The water powers of the Rhine near Laufenburg. (1,600 words & fig.)

1907 **621** .132.5 & **621** .134.3
Bulletin of the Railway Congress, No. 6, June, p. 646.

Santa Fe type Baldwin locomotive with superheater, Pittsburg, Shawmut & Northern Railway. (1,050 words & fig.)

1907 **621** .132.3
Bulletin of the Railway Congress, No. 6, June, p. 651.

Compound for the Mexican National. (750 words & fig.)

1907 **621** .134.3
Bulletin of the Railway Congress, No. 6, June, p. 653.

Progress in superheating. (1,400 words.)

1907 **621** .33 (.42)
Bulletin of the Railway Congress, No. 6, June, p. 655.

Metropolitan District Railway. (1,700 words.)

1907 **621** .33 (.45)
Bulletin of the Railway Congress, No. 6, June, p. 659.

Italian railway electrification. (100 words.)

1907 **656** .28 (01
Bulletin of the Railway Congress, No. 6, June, p. 659.

A railroad accident investigation bureau. (1,600 words.)

1907 **385** .581 (.73)
Bulletin of the Railway Congress, No. 6, June, p. 662.

Act limiting hours of service of railway employes in the United States. (900 words.)

1907 **621** .13 (02 & **385**. (04
Bulletin of the Railway Congress, No. 6, June, p. 664.

New books and publications : Locomotive compounding and superheating, by J. F. Gairns. (450 words.)

1907 **621** .13 & **385**. (04
ulletin of the Railway Congress, No. 6, June, p. 665.

New books and publications : Les locomotives à Exposition de Liége (1905) (The locomotives at the Liége xbibition). (200 words.)

1907 **016** .385. (02
illetin of the Railway Congress, No. 6, June, p. 75.

Monthly bibliography of railways. — Books. (24 labels.)

1907 **016** .385. (05
illetin of the Railway Congress, No. 6, June, p. 78.

Monthly bibliography of railways. — Periodicals. 36 labels.)

Engineer. (London.)

1907 **621** .132.3
igineer, No. 2686, June 21, p. 638.

Locomotive for the Bombay, Baroda, and Central dia Railway. (200 words & fig.)

Engineering. (London.)

1907 **62**. (01 & **625** .143.3
gineering, No. 2163, June 14, p. 763.

The corrugation of rails. (2,000 words, 2 tables & fig.)

1907 **621** .132.3
gineering, No. 2163, June 14, p. 771.

Four-cylinder compound express locomotive for the nish State Railway. (150 words & fig.)

1907 **669** .1 (01
gineering, No. 2163, June 14, p. 791.

HARBORD (W. F.). — Physical properties of steel. 200 words, 7 tables & fig.)

Engineering Magazine. (London.)

907 **385** .517
ineering Magazine, June, p. 328.

ACOBS (H. W.). — The square deal to the railroad ployee. (1,900 words & fig.)

Engineering News. (New York.)

907 **62**. (01 & **691**. (01
ineering News, No. 22, May 30, p. 599.

xperiments on proportioning concrete to secure ximum strength and density. (5,000 words & fig.)

1907 **625** .245 & **656** .22
Engineering News, No. 23, June 6, p. 615.

A recording machine for dynamometer tests on railway trains. (1,800 words & fig.)

Institution of Mechanical Engineers. (London.)

1906 **621** .132.8
Institution of Mechanical Engineers, No. 4, Oct.-Dec , p. 651.

RICHES (T. H.) & HASLAM (S. B.). — Railway-motor-car traffic. (17,600 words, tables & fig.)

1906 **621** .14 & **621** .132.8
Institution of Mechanical Engineers, No. 4, Oct.-Dec., p. 753.

CLARKSON (T.). — Steam as a motive power for public service vehicles. (35,200 words & fig.)

1906 **656** .215
Institution of Mechanical Engineers, No. 4, Oct.-Dec., p. 865.

FOWLER (H.). — Lighting of railway premises : indoor and outdoor. (22,000 words, 6 tables & fig.)

Iron Trail. (Minneapolis.)

1907 **656** .28 (01
Iron Trail, May, p. 220.

HOAG (W. R.). — Railroad accidents — their cause and prevention. (4,700 words.)

Locomotive Journal. (Leeds.)

1907 **385** .1
Locomotive Journal, June, p. 269.

The financial and commercial side of railway business. (3,000 words.)

Railroad Gazette. (New York.)

1907 **625** .2 (06
Railroad Gazette, No. 25, June 21, p. 887.

Master car builders' reports. (10,000 words & fig.)

1907 **385**. (01 (.51)
Railroad Gazette, No. 25, June 21, p. 908.

The great interior trunk line of China. (2,500 words & fig.)

Railway Age. (Chicago.)

1907 **625** .14 (01
Railway Age, No. 1616, May 31, p. 835.

SCHAUB (J. W.). — The railway track of the past and its possible development in the future. (1,400 words & fig.)

1907 **625** .235
ilway Age, No. 1617, June 7, p. 870.

Steel passenger cars on the Pennsylvania Railroad. 00 words & fig.)

907 **621** .134.3
ilway Age, No. 1617, June 7, p. 877.

OSS (W. F. M.).— The Cole locomotive superheater. 0 words & fig.)

907 **621** .338
ilway Age, No. 1618, June 14, p. 959.

HAZELTON (H.). — The new steel cars of the Hudson npanies. (2,400 words & fig.)

Railway Engineer. (London.)

1907 **621** .132.3
ilway Engineer, No. 329, June, p. 169.

4-6-0 engines; Buenos Ayres and Pacific Railway. 0 words & fig.)

1907 **621** .132.3
ilway Engineer, No. 329, June, p. 181.

4-4-2 engines (with superheaters); Swedish State Rail- ys. (800 words & fig.)

Railway and Engineering Review. (Chicago.)

1907 **625** .151
ilway and Engineering Review, No. 21, May 25, p. 442.

An improvement in split switches. (900 words & fig.)

1907 **621** .138.2
ilway and Engineering Review, No. 21, May 25, p. 444.

Modern locomotive coaling stations. (2,500 words fig.)

1907 **625** .143.2
ilway and Engineering Review, No. 21, May 25, p. 448.

Broken rails. (3,200 words.)

1907 **625** .253
ilway and Engineering Review, No. 22, June 1, p. 463.

Air brakes on the New York Central electrical equip- nt. (1,800 words & fig.)

1907 **621** .32 & **625** .233
ilway and Engineering Review, No. 22, June 1, p. 465.

Electric lighting for railway trains. (2,000 words fig.)

1907 **625** .235
Railway and Engineering Review, No. 23, June 8, p. 481.

Steel cars for passenger trains, P. R. R. (3,200 words & fig.)

1907 **625** .231 & **625** .235
Railway and Engineering Review, No. 24, June 15, p. 522.

Harriman Lines all steel postal cars. (750 words & fig.)

1907 **625** .143.2
Railway and Engineering Review, No. 24, June 15, p. 523.

Proporties of vanadium steel and the rail situation. (1,100 words & fig.)

1907 **625** .246
Railway and Engineering Review, No. 24, June 15, p. 525.

Structural steel in freight car construction. (3,000 words & fig.)

Railway Gazette. (London.)

1907 **656** .253
Railway Gazette, No. 23, June 7, p. 535.

Illuminating semaphore signals. (650 words & fig.)

1907 **621** .132.6
Railway Gazette, No. 23, June 7, p. 537.

New tank locomotives for the Midland Railway. (500 words & fig.)

1907 **621** .33 & **625** .4
Railway Gazette, No. 25, June 21, p. 585.

The Charing Cross, Euston & Hampstead Railway. (2,500 words & fig.)

1907 **625** .14 (01
Railway Gazette, No. 25, June 21, p. 589.

CUENOT (G.). — Track deformations and their preventions. (2,000 words.)

1907 **385** .114
Railway Gazette, No. 25, June 21, p. 590.

FRY (L. H.). — The cost of locomotives, 1890-1907. (2,200 words & fig.)

1907 **625** .253
Railway Gazette, No. 25, June 21, p. 592.

PARKE (F. H.) & DUDLEY (S. W.). — Recent developments in air brake control apparatus. (2,800 words & fig.)

Railway Machinery. (New York.)

1907 **621** .132.3
Railway Machinery, June, p. 531.

KING (C. R.). — Italian Prairie balanced-compound locomotives, and their future. (1,800 words & fig.)

Railway Magazine. (London.)

1907 **625** .254
ailway Magazine, No. 120, June, p. 468.

SEKON (G. A.). — The Eames vacuum break. (1,600 ords & fig.)

1907 **656** .222.1 (.42)
ailway Magazine, No. 120, June, p. 496.

ROUS-MARTEN (C.). — British locomotive practice nd performance. (3,500 words & fig.)

ailway Maintenance and Structures. (New York.)

1907 **624**. (01
ailway Maintenance and Structures, May, p. 84.

HIGGINS (H. K.). — Replacement of bridges and lied structures. (9,500 words.)

Railway Master Mechanic. (Chicago.)

1907 **625** .216 & **625** .251
ailway Master Mechanic, June, p. 212.

Automatic connectors for air and steam. (1,400 words fig.)

outh African Railway Magazine. (Johannesburg.)

1907 **313** .385
uth African Railway Magazine, June, p. 169.

GOODISON (C.). — Railway statistics. (6,000 words).

1907 **625** .61 (09.1 (.68)
uth African Railway Magazine, June, p. 189.

GEDDIE (J.). — Estcourt-Weenen light railway, atal. (3,000 words & fig.)

Street Railway Journal. (New York.)

1907 **621** .33
reet Railway Journal, No. 23, June 8, p. 996.

West shore electrification between Utica and Syracuse. ,700 words & fig.)

1907 **625** .235
reet Railway Journal, No. 23, May 8, p. 1010.

Steel passenger cars for the Pennsylvania Railroad. ,200 words, 2 tables & fig.)

1907 **621** .331
reet Railway Journal, No. 23, June 8, p. 1014.

The electrical maintenance plants of the New York ntral & Hudson River Railroad Company. (3,800 words fig.)

1907 **621** .338 & **625** .235
Street Railway Journal, No. 23, June 8, p. 1028.

HAZELTON (H.). — The new steel cars of the Hudson companies. (2,800 words & fig.)

1907 **621** .33 (09.1 (.73)
Street Railway Journal, No. 24, June 15, p. 1052.

The Philadelphia & Western Railroad. (5,700 words & fig.)

Tramway & Railway World. (London.)

1907 **621** .33 (09.1 (.42)
Tramway & Railway World, June, p. 463.

London united electric tramways. (6,000 words & fig.)

In Italian.

Giornale del genio civile. (Roma.)

1907 **385** .113 (.45)
Giornale del genio civile, maggio, p. 276.

Il primo anno dell' esercizio ferroviario di Stato. (4,800 parole & 3 tavole.)

Ingegneria ferroviaria. (Roma.)

1907 **621** .135. (01
Ingegneria ferroviaria, nº 11, 1º giugno, p. 176.

KING (C. R.). — L'origine e lo stato attuale della locomotiva a sforzi equilibrati. (3,200 parole, 2 tavole & fig).

1907 **625** .216. (06.4
Ingegneria ferroviaria, nº 11, 1º giugno, p. 184.

GELL (M.). — Gli agganciamenti automatici all' esposizione di Milano. (1,400 parole & fig.)

1907 **621** .95
Ingegneria ferroviaria, nº 12, 16 giugno, p. 193.

Perforatrici elettriche. (1,500 parole & fig.)

1907 **621** .133.7
Ingegneria ferroviaria, nº 12, 16 giugno, p. 195.

MELE (V.). — Un epuratore per caldaie da locomotive. (2,000 parole.)

In Spanish.

Gaceta de los caminos de hierro. (Madrid.)

1907 **385**. (06.111
Gaceta de los caminos de hierro, nº 2643, 24 de mayo, p. 245.

Próximo Congreso Internacional de los ferrocarriles en Berna. (2,000 palabras.)

Transportes ferreos. (Madrid.)

1907 **385.** (06.111

Transportes férreos, nº 905, 1º de junio, p. 5325.

Congreso internacional de ferrocarriles. (1,000 palabras.)

In Dutch.

Ingenieur. ('s Gravenhage.)

1907 **385** .15

Ingenieur, nr 23, 8 Juni, p. 420.

SANDERS (T.). — Reorganisatie en staatsexploitatie van spoorwegen. (9,000 woorden & fig.)

1907 **621** .33 (04 (.492)

Ingenieur, nr 25, 22 Juni, p. 458.

SURINGAR (E. F.). — Het bedrijf der Haagsche Tramweg-Maatschappij. (4,600 woorden & fig.)

1907 **624** .63 (01

Ingenieur, nr 25, 22 Juni, p. 472.

Beproeving van vier boogbruggen in gewapend beton over den Staatsspoorweg Maastricht-Aken. (500 woorden, tafereel & fig.)

1907 **625** .13

Ingenieur, nr 26, 29 Juni, p. 483.

Vernieuwing der vakwerkbrug van 50 meters dagwijdte te Kedoeng-Djattie in den spoorweg Samarang-Vorstenlanden. (3,400 woorden, 2 tafereelen & fig.)

Vol. XXI. — No. 9. September, 1907. 12th Year of the English Edition.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[621 .132.8]

AUTOMOTORS AND LIGHT TRAINS ON THE ENGLISH RAILWAYS,

By Mr. FRAHM.

Figs. 1 to 3, p. 857.

(*Zeitung des Vereins.*)

Since 1904, railway operation by motors has progressed considerably in England; there is hardly a great company that does not use rail motors, and there is therefore reason to think that the difficulties that used to be foreseen (¹) have not proved insuperable. However, one difficulty that was pointed out and that brought the whole thing to grief about fifty years ago in England, has given rise and is still, it appears, giving rise to much investigation; for if the engine and car form one whole, as was originally the case, any damage to the engine lays up also the carriage, and inversely; under these circumstances, the result may cause serious inconveniences which do not occur if the locomotive is attached to independent carriages. Moreover, the boiler of a motor will generally put up less well with hard feedwater and will usually require a better quality of coal than a locomotive boiler; again, the control apparatus of a locomotive are stronger than those of a motor, so that, with the latter, defects in the boiler and machinery occur rather frequently. It is well known that this circumstance prevented the introduction of motors half a century ago, but it was hoped that these difficulties could have been surmounted thanks to the experience acquired since in the construction of locomotives. Such

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(¹) *Vide* No. 26, of 1904, the *Zeitung des Vereins deutscher Eisenbahnverwaltungen* which summarized the position of the subject in England in 1903. — *Vide* also the *Bulletin of the Railway Congress* for February 1905 (2nd part), p. 855 : " Traffic conveyed by automobiles (subject XX for discussion at the seventh session of the Railway Congress) ", by Messrs. Léchelle, E. Sartiaux and Kerommnès, and the *Proceedings of the seventh session* (Washington, 1905), vol. 3, p. XX-3.

a hope seems to have proved deceptive, for the necessity of separating the machine from the car soon made itself felt once again, and led to the construction of a kind of truncated locomotive which carries in front, on a four-wheeled chassis, the boiler and motor, while posteriorly it is arranged so that it can be slipped under the front of a carriage and connected to it by a pivot.

The London & South Western Railway, which was one of the first English companies to inaugurate a service of automotors (in 1903), has lately gone a step further in the direction of separating the engine and the carriage, by using small tank-locomotives for hauling light trains. It is an instructive point to notice, that the tendency then in England seems to be to return from the motor, with its engine and car invariably connected, *via* the truncated locomotive that can be disconnected from its car but does not by itself make up an independent vehicle, to the locomotive properly so called. As there are a large number of motors in existence, and as new ones are still being built, there will doubtless be an opportunity of comparing the service of automotors directly with that of trains, as can indeed already be done in some continental countries.

The small tank-locomotives employed by the English company to work trains in the neighbourhood of Plymouth, are devised to haul two carriages, and to possess the following principal dimensions :

Diameter of cylinder	0·25 metre (9 $^{13}/_{16}$ inches).
Length of stroke	0·35 — (1 ft. 1 $^{13}/_{16}$ in.).
Diameter of wheels	0·91 — (2 ft. 11 $^{13}/_{16}$ in.).
Wheel-base	2·44 metres (8 feet).
99 water tubes of 44 millimetres (1 $^{3}/_{4}$ inch) in diameter in the fire-box	11·0 sq. metres (118·40 sq. feet).
216 smoke tubes of 38 millimetres (1 $^{1}/_{2}$ inch) in diameter	35·2 — (378·90 —).
Heating surface, fire-box	6·8 — (73·20 —).
Total heating surface	53·0 sq. metres (570·50 sq. feet).
Grate area	0·88 sq. metre (9·47 sq. feet).
Working pressure	10·5 atmospheres.
Water tanks, capacity	2·3 cubic metres (500 English gallons).
Coal bunkers, capacity	1 ton.
Tractive effort	1,760 kilograms (3,880 lb.).
Length over buffers	6 meter (19 ft. 8 $^{1}/_{4}$ in.).
Weight in running order	24·4 tons.

The cylinders are situated obliquely outside, the two leading wheels are carrying wheels, the trailing are drivers. The locomotives are fitted with Walschaerts valve gear, the slide-valves being above the cylinders.

The two cars of the train are intercommunicating with a central corridor and a gangway (fig. 1). Each car is 14·65 metres (48 ft. 1 in.) in length, 2·60 metres (8 ft. 6 $^{3}/_{8}$ in.) in width and contains a single class; there are on each side of the corridor, seats placed crosswise accommodating two persons. The car attached to the locomotive is divided by a transverse corridor into two compartments, one giving accommodation for

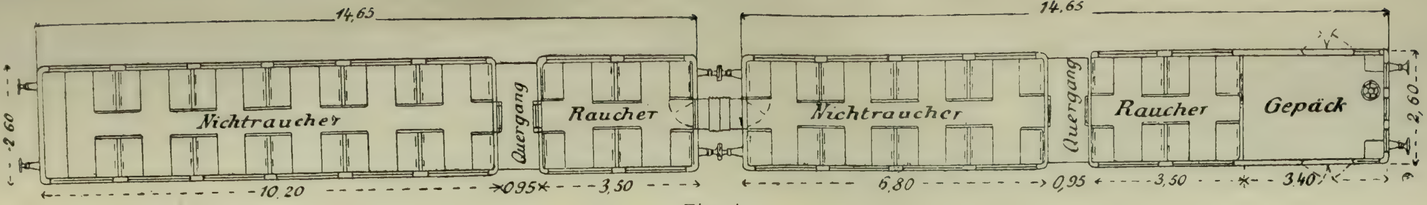

Fig. 1.

Explanation of German terms : Gepäck = Luggage. — Nichtraucher = Non-smoking. — Quergang = Transverse corridor. — Raucher = Smoking.

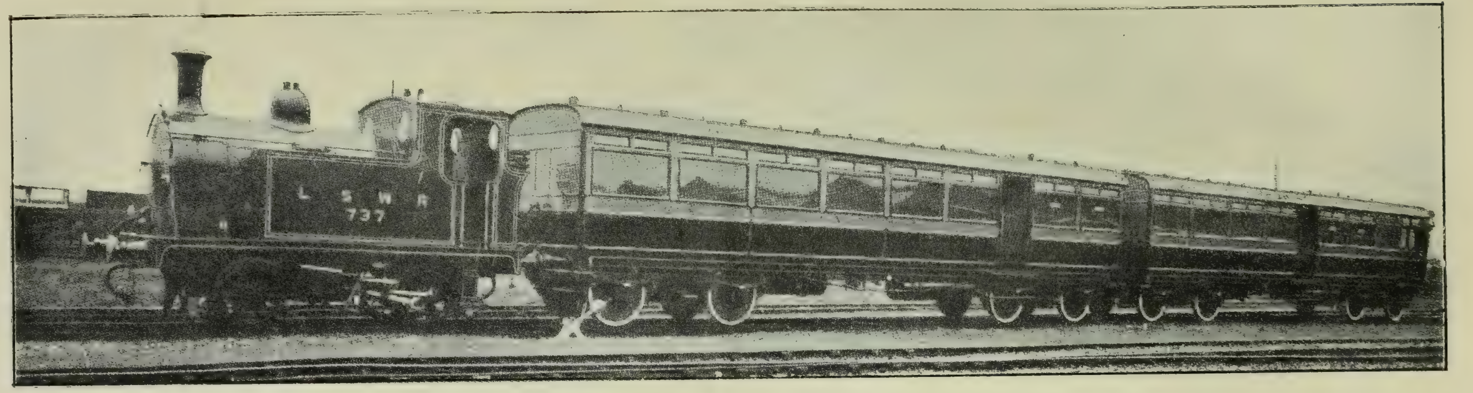

Fig. 2.

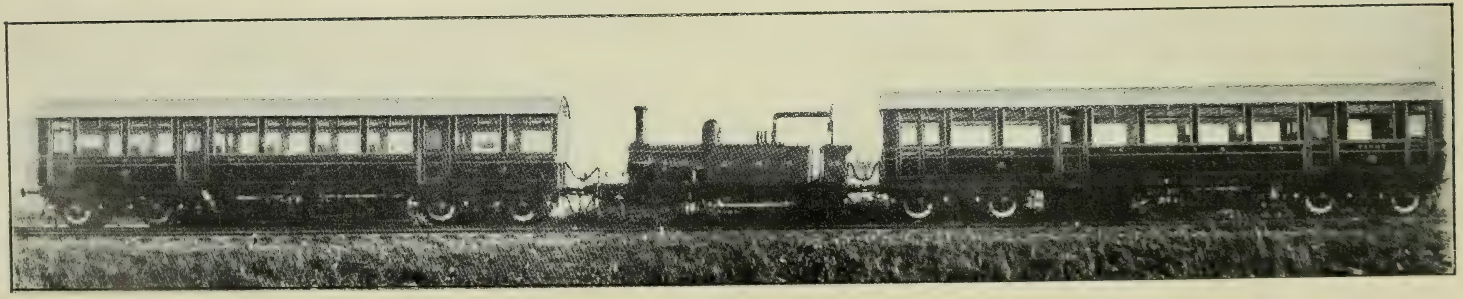

Fig. 3.

49 non-smokers, the other for 16 smokers. The second car has likewise a transverse corridor and two compartments, one for 32 non-smokers, another for 16 smokers and in addition, a van for the conductor and 1·5 ton of luggage. The car is decorated internally with mahogany and coloured photographs; the seats are made of strips of birchwood. The cars are steam heated and lighted with incandescent gas; the lamps are turned off and on by a single cock within easy reach of the train attendant. Each car is carried on two four wheeled bogies, the wheel base being 2·44 metres (8 feet); the distance between the pivots is 10·10 metres (33 ft. $1\,{}^{5}/_{8}$ in.) (fig. 2). The service compartment situated at the tail of this train, is fitted with an apparatus controlling the regulator of the locomotive, so that the train can be driven from either end; it has also a connection with the locomotive's whistle. The locomotive and cars are fitted with the automatic vacuum brake which can be worked either by the driver or the guard; moreover, each of these two has at his disposal a powerful hand brake. The company has ordered, to commence with, ten locomotives and six carriages for this service of light trains.

The North Eastern Company has, for some time past, been running some light trains of this kind, with the tank engines and carriages it already possessed, the locomotive being capable of being driven from both ends of this train.

The Great Northern of Ireland has lately put on its Dublin and Howth line a light train consisting of a tank-engine, weighing 32 tons in working order, which hauls, as may be required, one or two carriages. The cars are 16·15 metres (53 feet) long and 2·90 metres (9 ft. 6 ${}^{3}/_{16}$ in.) wide; at each end they have a service compartment. They have further, separate first and third class compartments and one for luggage. One of the cars accommodates 21 first class passengers and 38 third class, the other 9 first class and 56 third class. When the train is made up of two carriages, the locomotive is interposed between them (fig. 3). The train so made up is driven by the driver who stands in the service compartment situated in front. For this purpose, the regulator of the locomotive is connected by special shafts and levers with a controlling apparatus situated in this compartment. The same holds good when the train with one car is running backwards. The train does the journey between Dublin and Howth (13·2 kilometres [8·2 miles]) in twenty-two minutes, inclusive of four intermediate stops. We have not yet received any detailed information as to the results obtained with this service of a peculiar kind.

The tendency to provide greater elasticity in methods of conveying passengers by railway, is being followed generally in England and is justified by the circumstances. Everybody demands a more rapid means of travelling, and especially more frequent departures, electric traction having shown, both in railways and tramways, that a solution of traffic questions in this direction is possible. The tramways and even motor vehicles remove a considerable amount of traffic from railways; it is their competition which gave rise, some years ago, to the introduction of motors on railways. After a time, it seems to have next been discovered that motor services were suited to compete not only with tramways in the neighbourhood of towns, but also for working branches with light traffic, some lines upon which the traffic varies greatly according to the different hours of the day, and the new lines opened gradually and therefore not capable of being used straightaway throughout with heavy trains. An instance of this kind occurred a few years ago on the Great Western near London. It is especially on branches that the adoption of motors is thought beneficial, because this makes it possible, without growth of working expenses, to increase the frequency of departure and stopping places on the line, provided that the conditions (profile, water supply, etc.) are suitable. Thanks to this it has indeed been found practicable to improve the earnings on some branch lines. It should be noted that in England, they usually run passenger trains and goods trains proper, and not mixed trains, and this facilitates the adoption of these innovations. On the other hand, it does not seem that the simplification of the service by having a single class gives rise to any serious difficulties. The circumstances, however, are not similar everywhere. A large company, which works main and secondary lines, and which consequently can still utilize on the latter the old rolling stock of its main lines, will be less likely to decide to built motors than a small company that has no secondary lines. The South Western's light trains are run by three attendants (driver, stoker and guard) ; it remains to be seen whether two would not prove sufficient, one driver to run the train and one train attendant capable of helping the driver. In this case, there would have to be a communication between the locomotive and the carriage in front. The practice regulations (*Betriebsordnung*) in Germany provides for this in clause 63 which states that, on secondary lines, the government authorities may authorize the locomotive to be driven by a single individual provided that an attendant accompanying the train can easily while the train is in motion reach the driver's cab.

[625 .142.4 (.73)]

EXPERIMENTS WITH REINFORCED CONCRETE TIES IN AMERICA,

By W. M. CAMP,

MEMBER OF THE PERMANENT-WAY INSTITUTION.

Figs. 1 to 3, pp. 863 to 867.

(*Journal and report of proceedings of the Permanent-Way Institution.*)

The continual increase of railroad mileage and the rapid depletion of the forests in America, has brought railway managements in that country face to face with the problem of maintaining the supply of ties for the track. While wooden ties may still be had at a price considerably above that of a decade ago, the most desirable timbers are now too scarce to supply all the demand for them, and inferior woods are being used to a large extent. Formerly the white oak tie was standard practically everywhere east of the Mississippi river, and but few ties of other woods were used in main track. These ties now bring 70 to 80 cents (3*s*. to 3*s*. 4*d*.) apiece at many receiving points in the northern states, and what were once considered proper specifications for a first-class tie, cannot now be insisted upon so successfully as was the case when unlimited supplies of white oak timber were forthcoming. Southern hard pine and northern cedar must now be substituted in large part for situations where white oak is demanded. It will be but a few years until the supply of white oak ties throughout the whole country will be reduced to the actual accretions from growth of the timber, and that will be relatively small compared with quantities offered in the market at the present time. In all probability the demand for such timber for general manufacturing purposes will then be sufficient to put the price beyond any reasonable sum which can be paid for it for use in the track.

Under modern heavy rolling stock, the softer timbers cannot be used to advantage without protection by tie plates, the added cost of which puts the use of the soft timber on about the same basis as the cost of oak ties at the present time. Moreover, it seems certain that the domestic supply of even the inferior timbers must fail to meet the demands of the railways, before many years, not to consider what economy can be practised in the prolongation of the life of the ties by chemical treatment. At the present time, about 10 per cent of all ties purchased by the railways are being treated by some chemical process, and this percentage is likely to be increased somewhat.

The above statement is by way of showing that before many years American railway men must either look beyond their own shores for a supply of wooden ties, or else largely abandon timber as a track support. This situation began to be foreseen fully twenty years ago, and experiments to determine what substitutes for wood might be available were then undertaken, in a feeble sort of way, but soon discontinued altogether. As late as three years ago, the writer had occasion to ascertain that less than 5 miles of track would cover the combined length of all experimental sections that had ever been laid in the United States to discover or develop an available substitute for the wooden tie.

About six years ago, however, managements began to approach this question with some spirit of determination, and, particularly during the past two years, experiments with steel ties and reinforced concrete ties have been both numerous and perhaps reasonably extensive. At the present writing, no less than 52 1/2 miles of track is laid with steel ties, and quite 3 miles of track with reinforced concrete ties, on twenty-six or more roads in the United States, with the intention of laying at least 45 miles of additional track with steel ties this year on one road alone, and there are prospects for trying smaller stretches of both steel and reinforced concrete tied track on several other roads.

Without taking up in detail the question of steel ties, experiments with which have now become so interesting in America, it may be said that the results of the last six years of trial have demonstrated a fact of supreme importance, and that is, that at least one type of steel tie has been found that answers every requirement of track support fully as well as the best class of wooden tie. This type is represented by the so-called Carnegie I-beam tie, designed, experimented with, and fully developed by roadmaster C. Buhrer, of the Lake Shore & Michigan Southern Railway, at Sandusky, Ohio. This tie consists simply of a rolled steel I-beam 5 1/2 inches deep, with a top flange 4 1/2 inches wide, and a bottom flange 8 inches wide, with inexpensive bolts and clips to fasten the rail base to the top flange of the tie. The weight of such a tie 8 feet long, with fastenings, is about 160 lb., which, at the present price of steel, must cost not less than $2·25 (about 9*s.* 4*d.*). The original intention of Mr. Buhrer to have the tie rolled from re-heated scrap rails, thereby reducing the cost to some considerable extent, has not materialized as yet.

This brief account of the status of the most successful steel tie that has yet been used in America, leads up to the reason for undertaking experiments with reinforced concrete ties. Several thoughtful inventors had seen that a practicable steel tie could hardly be produced to meet the heavy requirements of American track with less than 150 lb. of metal. Therefore, the idea came to be widely entertained that a fraction of such weight of metal distributed as a reinforcement for a mass of concrete properly shaped, might render an equally serviceable and much cheaper tie a possibility. The history of the trials of such ties covers only a brief period, but already some dozen or more reasonable designs are being experimented with.

Before setting out to describe some of the most interesting of these experiments, it may simplify the understanding somewhat to indicate what expectations are sought to be fulfilled in the way of price. Owing to various uncertain elements associated with decrease of maintenance expense, which may be anticipated through ties of longer life, it is a difficult matter to closely compute the economy which may be realised by augmenting the service of a tie by any certain number of years, at a stated increase in the first cost. As yet the theories of even the most studious of this problem seem vague, and hence a rough approximation or a serious guess courageously advanced carries some weight. For a general statement, it may be said that inventors are working to the proposition that any tie which will survive twenty years of service will achieve the desired result if it can be produced at a cost not to exceed $1·50 (6*s.* 3*d.*). Even the most conservative will concede such to be the case as soon as the price of white oak ties reaches $1 (4*s.* 2*d.*). Let it suffice here to say that by that time the demand for the most serviceable ties of any kind will quite probably have operated to bring out some education on this point.

The beginning of experiments with reinforced concrete ties in America, was with a design worked out by Mr. J. J. Harrell, early in 1899. This tie consisted of concrete reinforced with a truss of 1-inch rods moulded in with the concrete. There was a horizontal top chord with a small vertical strut at the middle of it, and the bottom chord sloped both ways to the bottom of that strut, forming a sort of fish-belly truss. These ties were 7 ft. 4 in. long, and the cross section of the tie was the shape of an inverted " U, " with the sides somewhat sloping or flaring outward at the bottom. The bottom width of the tie at the ends was 10 inches, and the depth 8 $^1/_2$ inches. The bearings for the rails might be called tie plates. They were steel plates about 4 inches wide, set in the concrete. The rails fastenings consisted of bolts and clips, the bolts anchored in the tie, being attached to the ends of the reinforcing truss.

These ties were put into the track of the Pittsburg, Fort Wayne & Chicago Railway that summer, just a short distance south of the Union Station, in Chicago, where they had to carry very heavy traffic. Thirty of the ties were laid under 85-lb. rails, on a 6 $^1/_2$-degree curve, in stone ballast. They had not been in the track long before two of the ties cracked across the middle, but the reinforcement held them together. They went through the next winter alright, and seemed to stand the frost in good shape, as far as the solidity of the concrete was concerned, but the trouble which eventually led to failure was with the fastenings. The rails began to spread on a tie at a time, and that spreading was due to the bolts working loose. The fastening bolts were too small, being only $^5/_8$ inch in diameter. The flexure of the rails worked the bolts loose and the rails began to pound the bearing plates, so that entire failure was then only a matter of course. The next spring the rails began to spread, and the reinforced concrete ties were gradually renewed with wooden ones, taking out a defective concrete tie and putting in a wooden one, until the former were all removed. The larger part of them remained in the track seventeen months, and some of them were in service two years.

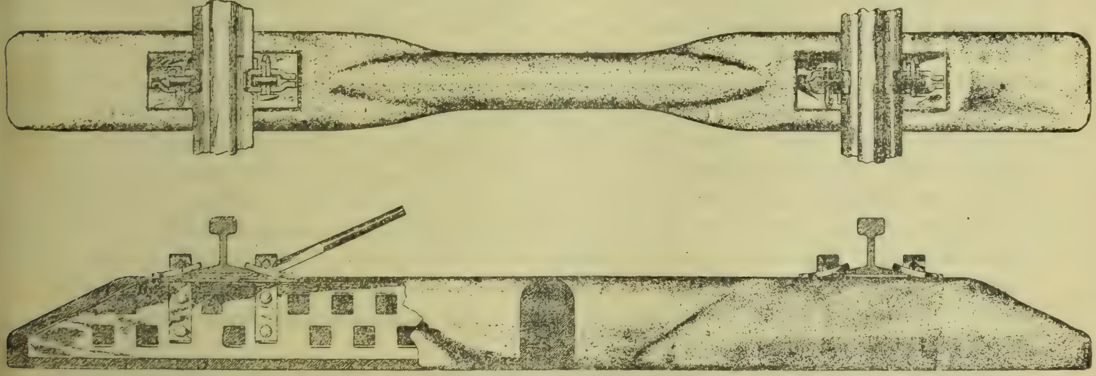

Fig. 1. — Improved Harrell reinforced concrete tie.

Profiting by this experience, Mr. Harrell re-designed the tie on improved lines, as seen in figure 1. This time the reinforcement consisted of a steel plate $^1/_4$ inch thick, 7 inches deep, and 7 ft. 8 in. long. The upper corner of each end of this plate was slitted lopped over each way. The plate was also perforated at frequent intervals by cutting around three sides of a square hole and bending over the tongue of metal, to give the frame a firm hold in the concrete. The bearing for the rail consisted of a plate 5 inches wide, 14 inches long, and $^3/_8$ inch thick, resting upon the top of the frame and upon the concrete. The fastening for the rail consisted of a pair of straps riveted to the frame or web plate, and projecting up through the tie plate or rail seat. The rail was held to the plate by spring links, which straddled the straps and were held in place by common track spikes run through slots in the straps after springing the links down with a bar.

The tie was 8 feet long, over all, and 8 $^5/_8$ inches deep. Each end of the tie, for about one-third of its length, was 9 inches wide on bottom and 5 inches wide on top. The middle third of the tie was 5 inches thick, and the bottom corners were rounded, to restrict the bearing surface and prevent center-binding of the tie. The tie weighed about 300 lb., of which 55 lb. was metal. The concrete in these ties was made of crushed limestone and Portland cement in a very wet mixture. The stone for the mixture was "crusher run" of $^5/_8$ inch size and smaller, no attempt being made to separate the dust, which was thought to produce a stronger concrete than could be made by the use of sand.

Mr. Harrell received quite a handsome order for ties of this design, but through some difficulty arising after a company had been organised to manufacture them, they were never made in quantity. The few which were produced were placed in a side track at Hegewisch, Illinois, in 1901, where, from last accounts, they were doing well. As they were not subjected to main-track service, it would be unfair to place a high estimate on their record, and they were too few in number for an effective demonstration. The reason for mentioning Mr. Harrell's experiments so prominently, is that he was the pioneer in the trial of reinforced concrete ties, and his second or improved design seemed worthy of remark as a particularly strong and well-studied piece of work.

The next year (1902) brought out two more independent designs of reinforced concrete ties, which have received noteworthy trials. Mr. George H. Kimball, then chief engineer of the Pere Marquette Railroad, designed and put into service the tie shown by the drawings in figure 2 (¹). It consists of two bearing blocks of concrete, each 3 feet long, with rounded cheeks like a wooden pole tie. Each of these blocks is 7 inches deep, and the face is 9 inches wide. Each pair of concrete blocks is joined by two channels 3 inches deep, with 1 $^1/_4$ inch flanges. The weight of the channels is 4 $^1/_2$ lb. per foot, and they are placed 2 inches apart, back to back, and moulded in with the concrete blocks. The bearing of the rail is taken by a 4 × 9 inches white oak block 18 inches long. This block is secured to the concrete base by $^1/_2$ inch square bolts moulded into the concrete block and jointed at the top surface thereof by means of a screw socket. The top head of the bolt is countersunk into the wood, and the space around the same is filled with pitch, to exclude water. The wooden blocks are treated with carbolineum. To these blocks the rail is spiked in the usual manner, but the use of clips has also been considered. In places where a wooden block is used that is thinner than the length of the spike, elm plugs are moulded into the concrete block and bored for the spikes.

The method of connecting the anchor bolts to the channels is by a pin projecting into the concrete about 1 inch from the side of the channel, thus giving the channel a secure hold in the masonry. The exposed surface of the channels between the blocks is protected by two coats of

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(¹) Vide *Bulletin of the Railway Congress*, No. 8, August, 1902, p. 661.

Portland cement mortar, spread on thin, and to further protect the steel from corrosive action, the space between the channels is filled with concrete.

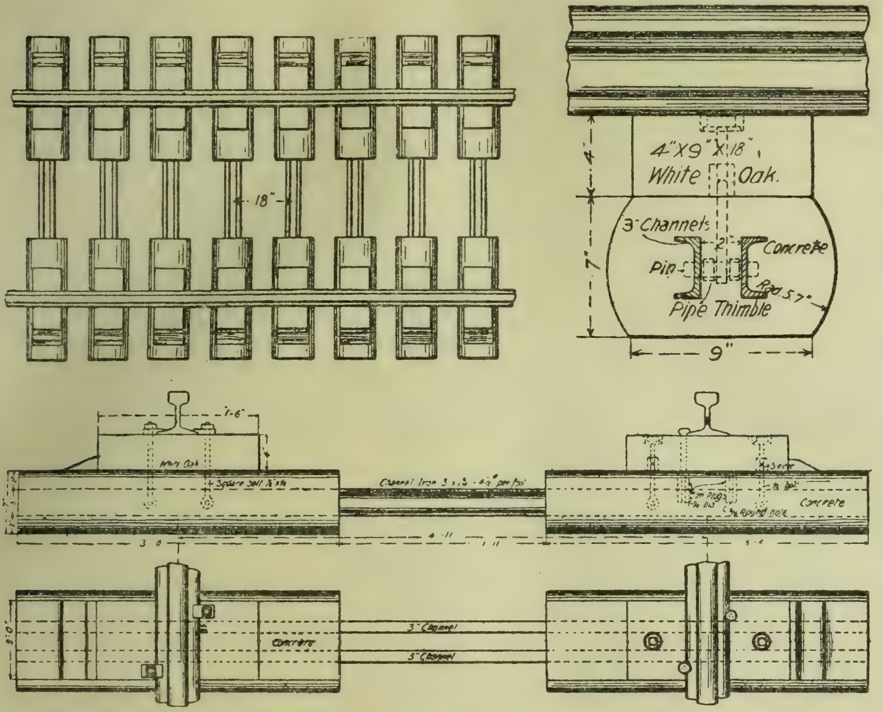

Fig. 2. — Kimball reinforced concrete tie.

The concrete in the bearing blocks consists of two parts of Portland cement, one part of sand, and three parts of screened gravel that will pass through a $^3/_4$ inch wire mesh. The blocks are moulded to the ends of the channels under a pressure of 10 lb. per square inch. The weight of the tie is about 452 lb., including 68 lb. of metal, 374 lb. of concrete, and 10 lb. of wood block.

The other inventor who came out with a reinforced concrete tie in 1902, was roadmaster C. Buhrer, of the Lake Shore & Michigan Southern Railway, already mentioned as identified with the development of steel ties. His tie consists of an inverted piece of scrap 65 lb. rail, 7 $^1/_2$ feet long, with the original base of the rail serving as the top face of the tie, the concrete body of the tie, 6 $^1/_2$ inches deep and 9 inches wide on bottom, being moulded about the downwardly-turned head of the old rail. This reinforcement is unnecessarily strong, as was understood at the beginning, being purposely made such to ascertain whether concrete can, with the assistance of enough steel reinforcement to alone withstand the bending strains to which the tie is subject, maintain a solid body for the tie. The inventor considers that an inverted T-shape or bulb iron, weighing 75 or 80 lb. will afford an ample reinforcement. The rail is fastened to the tie by means of clips held by bolts passed through the steel top face of the tie. The cost of making the tie is 42 cents (1*s*. 9*d*) in addition to the cost of the reinforcement, which, at the present market price of steel, cannot be less than $1·05 (4*s*. 5*d*.).

A curve of the Lakeside & Marblehead Railway, at Danbury, Ohio, was laid with 550 of these ties. This track is subject to heavy freight tonnage, and before these ties were used, difficulty was experienced in keeping the rails in gauge and alignment. Through excessive spiking the ties would be cut out long before rotting set in, and from first to last the maintenance expense was heavy. This curve, which is one of 12 degrees (radius 478 feet), was laid with these ties in July, 1903. Since then there has been no trouble whatever with the gauge or with the alignment, and the track has been maintened with but very little labour of any sort. The record of these 550 ties in three and a half years has been only ten failures. In other words, 540 of these ties are still in service without any apparent deterioration, and good for years to come. While the traffic at this point is heavy, the speed is not fast, and the management of the road and the inventor of the tie seem to be warranted in the conclusion that for such conditions, track can be laid with reinforced concrete ties which will last a lifetime, with only such failures as can be traced to faulty work in moulding the concrete.

During June, 1902, ties of this design had been laid in the main track of the Lake Shore & Michigan Southern Railway, at Sandusky, Ohio, and in July of that year, another experimental lot were laid in the main track of the Chicago & Northwestern Railway, at Milwaukee, Wisconsin. Since then, trial sections of track have been laid with these ties by the Ann Arbor Railroad, near Durand, Michigan; by the Pennsylvania Lines West, at Toledo, Ohio, and by the Lake Shore & Michigan Southern Railway, at many points. Something like 6,000 of these ties are in use on the Lake Shore & Michigan Southern Railway alone.

When this tie is used under the track circuit of automatic electric block signals, which are now standard in America and being rapidly extended over all the important lines of railway there, one of the rails must be insulated from the ties. Such is not the case with the Kimball reinforced concrete tie and some others.

The Elgin, Joliet & Eastern Railway is experimenting with a reinforced concrete tie designed by Mr. R. B. Campbell, its general manager (1). The main body of this tie is rectangular in cross section, 7 inches wide and 6 inches deep, with bevelled corners top and bottom. Under the rails, the tie is enlarged to a width of 10 inches. The length of the tie is 8 1/2 feet. The reinforcement consists of two scrap boiler flues of 2 1/4 inches outside diameter and 7 feet long, laid side by side and staggered, so that their ends overlap 7 1/2 inches. An additional reinforcement of common chicken wire netting is placed around the tubes, as shown in figure 3, and a piece of heavy wire netting, 6 × 8 inches, is inserted in slots in the tubes, directly underneath the rail seats. The bearing for the rails consists of tie plates, and the fastenings consist of U-bolts, which pass through the tie from underneath, extending up through the tie plate and screwed down upon clips which hold the rails in place. The cost of manufacturing this tie in quantities is estimated at $1·50 to $1·75 (6*s*. 3*d*. to 7*s*. 4*d*.) each. On September 7th, 1904, 65 of these ties were placed in one of the main switching leads of the Elgin, Joliet & Eastern Railway, where they have been subjected to the heaviest service possible, and no failure or deterioration has been observed. They have maintained the track in good surface and line, and apparently the frost has not affected them in the least.

Sixteen of these ties were put to breaking tests in a testing machine. With the load applied at the centre of the tie, the weakest broke at 4,000 lb. and the strongest at 9,800 lb., the deflection at a loading of 9,600 lb. being 0·415 inch. When the loading was applied at 9 inches from each end, the tie inverted and supported at the rail seats, the weakest broke at 11,400 lb., deflection 0·465 inch; and the strongest at a loading of 14,200 lb., deflection 0 572 inch. When subjected to a crushing test, with pressure applied at the rail seat to a 10 $^1/_2$ × 11 $^1/_2$ inches plate on top of the inverted tie, and a 4 $^1/_2$ × 12 $^1/_2$ inches plate beneath it, a crack appeared at a loading of 80,000 lb. and complete crushing at 100,000 lb. The crushing load resisted was equivalent to 1,350 lb. per square inch of material.

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(1) Vide *Bulletin of the Railway Congress*, No. 8, October, 1905, p. 2238.

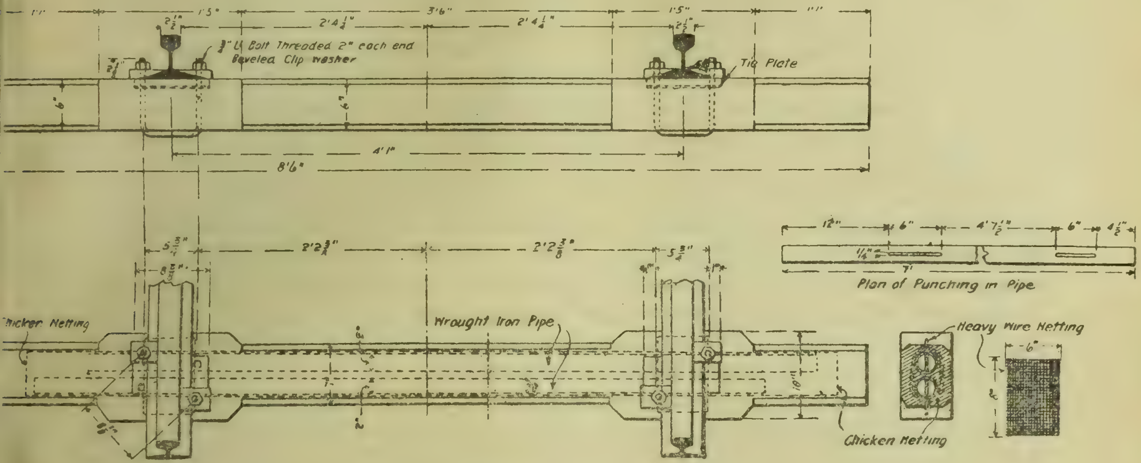

Fig. 3. — Campbell reinforced concrete tie.

Another distinct type of reinforced concrete ties is the Percival design, first laid in the track of the Galveston, Houston & Henderson Railway, at 43rd Street, Galveston, Texas, on June 28th, 1905. These ties are 8 feet long, 9 inches wide on top face and 10 inches deep. On the bottom each end of the tie is ovalshaped for a length of 3 feet, with an average bearing of about 5 inches. For a length of about 2 feet at the centre, the bottom of the tie is V-shaped. Each tie is reinforced with four corrugated steel bars running parallel and tied across, the total weight of such reinforcement being 24 lb. The rail rests on a treated hardwood cushion block, 1 $^7/_8$ × 9 × 14 inches. Sockets are cast in the tie and filled with a composition of galvanized cut wire and babbit metal, arranged to receive a screw spike $^7/_8$ × 10 inches, which holds the rail in a firm manner, and it can be easily and cheaply renewed at any time. The ties have been under heavy road and switching traffic, and the report of the latest examination of them states that they were in good condition, and no sign of deterioration was in evidence. A further test of these ties is being made by the Pittsburg & Lake Erie Railroad.

Less extensive experiments with several other interesting patterns of reinforced concrete ties might be cited, but, in the opinion of the writer, the foregoing have brought out the most valuable information in such use of concrete as known to date. It remains, therefore, to draw such conclusions as can be formed at this time regarding the future success of this class of tie.

At the outset, it must be admitted that some of the experiments with strongly-constructed reinforced concrete ties have resulted in partial failure, but the time since the first trials began is still too brief to assume that certain defects cannot be overcome. The most pronounced failures have been with concrete reinforced with a multiplicity of small rods or bars, not described in the foregoing account. It therefore seems reasonable that the only style of reinforcement which can be expected to meet with any success must, of itself, independently of the concrete, constitute a substantial structure or member. Again, it would not be discreet to predict at this time ultimate success for any particular design of tie which has been tried only in small numbers, however promising the outlook, as will be shown later on. We should, therefore, look more particularly to the experiments which have been carried out on the most extensive scale.

From the standpoint of magnitude, the man who has outdone all others in studying, designing, and developing both steel and reinforced concrete ties, in America, is Mr. C. Buhrer. His ties have not only been tried on more railways than have any other design, but he has caused to have constructed and put into actual service more ties of the two varieties named than have all other inventors in America combined. Looking to his experience it is significant of a preceding observation that the trial sections of track laid down during the first year of his experiments have withstood heavy traffic in main track without failure or deterioration of any sort, while some experiments on a larger scale, with the same make of tie placed in subsequent years, have not been entirely successful. At some points, none of the ties have failed during three or four years, but at other points, a considerable percentage of the ties have failed. At certain points, these ties have been subjected to the severest tests possible, being in track where there is a heavy freight traffic and heavy passenger trains passing at speeds frequently as high as 80 miles per hour. In three instances, loaded cars have been derailed and hauled over these ties without fracturing any of them, although clip bolts were sheared off.

That the experience of the Lake Shore & Michigan Southern Railway has demonstrated the practical worth of these ties, may be known from the following considerations : 1° most of the failures may be traced to faulty or careless workmanship in mixing the materials and moulding the ties; 2° at several points where main track has been laid with these ties, there has been no deterioration whatever after three and four years of service; 3° the material of the tie has not been affected by frost or fire.

The engineering department of this road has arrived at two conclusions, namely : track laid with these ties is too rigid for high-speed trains when the ground is frozen, and it is probably impracticable to construct a tie body of concrete which will carry heavy and fast trains without a considerable percentage of breakages after a term of years. It is, however, considered the ideal tie for side tracks and yard tracks, or for any track which does not carry fast traffic. For such service, it is considered superior to a steel tie. Side-tracks laid with these ties and well surfaced will need practically no attention for long periods. This is the policy now pursued by the Lake Shore & Michigan Southern Railway with respect to reinforced concrete ties, and a number of side-tracks have already been laid with them. It is also being used in tracks of any class, opposite water stations and at other points where the ashpans of locomotives are dumped, resulting in rapidly burning-out wooden ties. Mr. S. Rockwell, chief engineer of that road, has no hesitation in recommending the tie as one of long life for any track carrying slow traffic.

[625 .143.2 (.73)]

FOR BETTER RAILS

Figs. 1 to 13, pp. 879 to 884.

(*The Railroad Gazette.*)

It is perhaps safe to say that there is no more striking example in this country of the dangerous and harmful possibilities of a great corporation than that which is now being afforded by the United States Steel Corporation in its attitude towards demands for sound rails. There is no individual, or combination of individuals, which knows better how to make good rails than does the United States Steel Corporation, with its splendid army of experts. Nevertheless, it knowingly makes rails which break and kill people. The top of ingots are not being cropped off below the point where high phosphorus and impurities are found; specifications, as furnished by railroad companies, are totally disregarded, and rails, especially in the new and heavier sections, are furnished with spots in them so full of impurities and so brittle that they must of necessity break when subjected to the strain of traffic. The Steel Company knows this quite well. The railroad companies also know it quite well. The Steel Company declines to take cognizance of the fact, because this would mean considerable reduction of output although no important loss of material. The railroad companies fail to take a firm stand because, in the interests of the tremendous traffic, which they derive directly and indirectly from the steel companies, they have not yet dared to do so.

Two points here are specially noteworthy : firstly, the criminal willingness of the Steel Corporation and the companies allied with it to manufacture rails that cost human life; secondly, the attitude, almost equally criminal, on the part of many high railroad officers, to ignore the plain truths that are being brought before them by their superintendents and chief engineers. At the recent meeting of the American Railway Association in Chicago, it was asked by G. L. Peck, general manager of the Pennsylvania Lines West, that any representative of the 230,000-odd miles of railroads in the United States present at the meeting who was satisfied with the rails he was receiving, should get up; nobody got up. The representatives of the steel manufacturers who were asked to defend their processes of manufacture, had nothing to say.

It is obvious that such a state of affairs as this cannot continue, for public safety is involved. Since the year 1901, it has been impossible for railroad companies to have their specifications adhered to. The tremendous increases in rail breakages during these five years, when the Steel Corporation has had the matter in its own hands, are well shown in the tables of rails broken and taken from track in New York State, which are shown in another column. During January, February and March, 1907, 836 rails, rolled in the previous year, were broken and taken from track in the state of New York as against 29 rails, rolled in the year 1901, which broke during the same period. This record may be directly characterized as disgraceful — a disgrace to the reputation of the rail manufacturers, who are fully able to remedy the known defects if they wish to do so. The only answer which the rail manufacturers have brought against the charge is that traffic has grown materially heavier in the last few years, and that track structures, ballast, etc., are insufficient for the strain which is put upon them, with the result that high spots and low spots occur in the track, causing breakages which cannot be avoided. They suggest as a remedy the use of a still heavier rail section, weighing perhaps 150 lb. to the yard. But it has been conclusively shown that the 100-lb. rails of 1905, 1906 and 1907 have made a far worse record in breakages than the 80-lb. rails rolled five years ago; it is evident therefore, that no help is to come from increased weight of section until better processes of manufacture are co-ordinately employed. The exact details of specification, already quite generally agreed upon, and the proper shape of the cross-section, not so fully agreed to, need not be discussed at present. The trouble at the root of the present situation, does not lie here. Heavy rails of the present day are materially deficient owing to three causes, capable of considerable subdivision, which can be outlined roughly as below :

1° Phosphorus and impurities which collect in the top of the ingot during cooling require that about one-third of the ingot should be cut off before the rails are rolled. Present practice in the steel mills cuts off a much smaller amount than this, leaving the ingot full of impurities, and with its phosphorus much higher than that allowed by the best specifications;

2° With the Bessemer process and the ores now used, it is extremely difficult to keep down the phosphorus. A high phosphorus content with high carbon added to give hardness and wearing qualities, makes brittle steel. Open hearth rails, of course, furnish the solution of this difficulty;

3° In the efforts for output, rails are being finished at too high a temperature, and are not receiving enough work in the rolls. Before this can be completely remedied, it is probable that some change in the form of the cross-section will be necessary, but many of the gravest defects arising from rolling can be remedied while the section remains in its present shape.

The recent action of Mr. Harriman in ordering 150,000 tons of open hearth rails from the Tennessee Coal & Iron Company, and in throwing down the gage to the Bessemer steel makers, adds much interest to the present situation. Mr. Harriman and his system are both big enough to be above the necessity of the traffic diplomacy that ties most of the railroads hand and foot, in a crisis like this. He reported 449 rails braken on his lines during February, of which 179 were 90-lb. rails that had been in the track only five or six months, and accepted Mr. Kruttschnitt's suggestion that damage claims should be instituted against the steel companies for the preventable harm thus done. By taking this position, he has greatly strengthened the hands of the committee of the American Railway Association.

A collection of letters, bearing on this subject, which we regret we must print unsigned and unidentified, will be found in another column accompanied by a series of photographs of broken rails, which constitute a terrible document of the utter lack of responsibility which has characterized the steel companies within the last few years in supplying such a product, upon the strength of which human lives depend. The United States Steel Corporation definitely refuses to make rails according to specifications of chemical composition and details of rolling, while at the same time, it is selling rails to the Japanese government for 10 dollars a ton less than the price in this country, and is adhering to the required Japanese specifications.

A careful reading of these letters from railroad officers, makes it apparent that the roads which have suffered have been those combining heavy rails and heavy axle loads; that is to say, that the rails now made to carry maximum traffic are not capable of always performing their task. The need for a better and more scientifically unified railroad superstructure to carry great train loads, is admitted by all. Mr. Cuenot, the French engineer, discusses some of these superstructure problems in the serial papers which we are now printing. But defects in superstructure do not excuse gross imperfections in 100-lb. rails! How gross these imperfections have become, a glance at the photographs hereafter will show.

The rails furnished by the steel companies in this country have become so bad within the last five years, especially rails of 100-lb. and other heavy sections, that the American Railway Association is now investigating the matter, and proposes to ask the United States Steel Corporation to furnish specifications of chemical composition and manufacture, and then adhere to those specifications. We have collected a number of letters bearing on this subject from railroad officers, whose names we are not at liberty to disclose, and print extracts from them herewith. We also show the radical results found in the recent investigation by the New York Railroad Commission. It will be observed that 495 rails of 100-lb. section were broken and removed from the main line of the Lake Shore & Michigan Southern in New York State during the first three months of the current year, out of a total of 505 rails broken. Also that 475 100-lb. rails broke on the New York Central main lines east in New York within the same period, out of a total breakage of 477 rails. On the main line of the Mohawk division, 217 100-lb. rails broke in three months; on the western main lines (within New York State), 107 100-lb. rails broke. The total number of 100-lb. rails broken within the state in January, February and March was 1,295; a disgraceful record, for which the Steel Corporation is mainly responsible, as proved by the much lesser breakage of older rails, rolled according to specification. As pointed out above, the companies have been unable to insist on their specifications since 1901, but have been forced to take what was given them. The kind of rails they receive are shown in the accompanying photographs.

Letters from railroad officers follow :

" I regret to say that the records of our maintenance of way department have not, until

Rails broken and taken from track during January, Feb

Compiled by New York

NAME OF RAILROAD.	DIVISION.	1905													
		Weight of rail per yard.													Total.
		56	58	60	65	67	70	72	75	76	80	85	90	100	
Delaware & Hudson	Susquehanna	...	...	...	...	...	...	...	...	...	36	...	...	...	36
— —	Saratoga.	...	...	...	...	...	...	...	...	...	12	...	...	...	12
— —	Champlain	...	...	...	...	...	...	...	...	...	12	...	...	...	12
Lehigh Valley	Main Line	...	1	...	...	...	...	...	...	...	73	...	26A 1L	...	101
— —	Branches.	2	6	10	...	1	...	...	...	2	3	...	...	...	24
Rutland	O. & L. C.	...	...	...	...	...	...	1	1	...	8	...	...	...	10
—	Chatham.	...	...	...	...	...	...	...	...	...	...	...	...	...	0
New York, New Haven & Hartford		...	...	...	...	...	3	...	7	...	...	...	...	...	10
Boston & Maine.	Main Line	...	...	...	...	...	...	3	...	10	...	3	...	...	16
— —	Branches	...	...	6	...	...	...	10	...	2	...	...	...	...	18
Buffalo, Rochester & Pittsburgh	Rochester	...	...	...	...	...	...	...	...	...	13	...	...	...	13
— — —	Buffalo	...	...	...	...	...	...	...	...	...	13	...	1	...	14
New York, Ontario & Western	Main Line	Unable to furnish information.													
— — —	Branches						—		—			—			
Pennsylvania (B. & A. V. Division)	Chautauqua.	...	...	...	...	6	3	...	...	...	...	1	...	...	90
— (— —)	Buffalo	...	...	...	...	...	...	...	...	...	...	...	...	...	0
— (— —)	Rochester Branch.	16	...	...	...	33	...	...	...	...	1	...	...	...	50
Lake Shore Railway	Main Line	...	...	...	5	...	...	...	...	...	222	...	...	...	227
New York Central & Hudson River Railroad	Main Line East	...	...	...	...	...	...	...	...	...	5	...	...	199	204
— — — — —	— — Mohawk	...	...	...	...	...	...	...	...	...	109	...	...	...	109
— — — — —	— — Western	...	...	...	...	...	...	...	...	...	71	...	...	...	71
— — — — —	Branches Eastern.	...	...	1	...	...	...	...	...	...	2	...	...	...	3
— — — — —	— Mohawk	...	...	...	...	16	...	...	6	...	11	...	...	...	33
— — — — —	— Western	...	...	...	2	6	...	...	...	...	...	...	...	...	8
— — — — —	— R. W. & O.	...	...	9	...	...	9	...	...	...	4	...	...	...	22
— — — — —	— River Division	...	...	...	...	...	...	...	...	...	14	...	...	...	14
— — — — —	— Pennsylvania Division.	...	...	...	...	...	...	...	2	...	3	...	...	...	5
Erie.	Main Line New York	No record.				...	...	...	...	...	...	...	...	...	...
—	— — Delaware.	—				...	...	...	...	...	...	...	4	...	4
—	— — Susquehanna.	...	...	...	...	...	...	...	...	...	29	...	26	...	55
—	— Allegheny	...	...	...	...	...	...	...	...	...	...	...	1	...	1
—	— Buffalo	No record.				...	...	...	1^{74}	...	1	...	...	...	2
—	Branch Line Rochester	—				...	...	...	...	...	...	...	...	...	...
—	— — Greenwood Lake	...	...	...	...	...	...	...	...	...	...	...	...	...	...
—	— Goshen Deckertown	...	...	...	...	...	...	...	...	...	...	...	...	...	...
—	— Buffalo & South Western	...	...	...	...	...	...	...	9^{74}	...	...	...	...	...	9
—	— Meadville Division.	...	...	...	...	...	...	...	...	...	...	...	5	...	5
	Total.	18	7	26	7	142	15	14	26	14	642	4	64	199	...

arch, 1905, 1906 and 1907, in New York State. -

ad commissioners.

1906															1907																	
Weight of rail per yard.													Total.	Grand total.	Weight of rail per yard.																Total.	Grand total.
58	60	65	67	72	74	75	76	80	85	90	95	100			56	58	60	65	67	70	72	75	76	78	79	80	85	90	95	100		
...	...	...	...	...	...	...	...	32	...	...	...	...	32	...	...	...	...	...	...	...	...	...	...	...	...	...	...	64	...	...	64	...
...	...	...	...	...	...	...	...	9	...	...	...	...	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	3	...
...	...	...	...	...	...	...	...	19	...	...	...	...	19	60	...	...	...	...	...	...	...	...	...	...	...	...	...	26	...	...	26	93
...	...	...	...	...	...	...	...	23	...	10A	...	...	33	...	...	1	1	...	...	...	...	...	...	...	...	32	...	26A 12L	...	...	72	...
4	3	...	...	...	...	...	2	5	...	...	...	...	17	50	10	4	1	...	...	...	...	...	3	...	...	13	...	...	...	...	31	103
...	...	...	...	2	...	1	...	4	...	...	...	...	7	...	...	...	...	...	...	...	1	...	...	...	...	6	...	...	...	...	7	...
...	...	...	...	...	...	...	...	...	...	...	...	...	0	7	11	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	13	20
...	...	...	...	...	1	...	...	...	...	...	...	1	2	2	...	...	...	...	...	...	...	1	...	26	1	...	...	...	...	1	29	29
...	...	...	...	...	...	...	2	...	5	...	...	...	7	...	...	...	...	...	...	...	...	...	2	...	...	...	3	...	...	...	5	...
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...	...	...	...	...	...	...	...	3	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	13	...	119	...	...	132	...
...	...	...	...	...	...	...	...	1	...	...	...	...	1	4	...	...	...	...	...	...	...	...	...	...	...	...	...	124	...	...	124	256
...	...	...	...	...	...	...	13	...	...	...	4	...	17	...	...	...	...	...	...	...	...	...	4	...	...	...	...	...	4	...	8	...
...	...	...	3	...	...	...	...	...	...	...	...	...	7	24	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	10
...	...	...	126	...	...	...	...	...	3	...	...	...	129	...	...	...	...	...	92	4	...	...	...	...	...	...	9	...	...	...	105	...
...	...	...	...	...	...	...	...	1	16	...	...	...	17	...	...	...	...	...	...	...	...	...	...	...	...	3	61	...	...	...	64	...
...	3	...	21	...	...	...	...	12	...	...	...	...	40	186	10	...	...	...	19	...	...	...	...	...	...	5	2	...	...	...	36	205
...	...	2	...	...	...	...	...	16	...	...	...	16	34	34	...	...	...	4	...	...	...	...	...	...	...	6	...	...	...	495	505	505
...	...	...	...	...	...	...	...	3	...	...	...	65	68	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	475	477	...
...	...	...	...	...	...	...	...	108	...	...	...	8	116	...	...	...	...	...	...	...	...	...	...	...	...	121	...	...	...	217	338	...
...	...	...	...	...	...	...	...	56	...	...	...	7	63	...	...	...	...	...	...	...	...	...	...	...	...	57	...	...	...	107	164	...
...	...	2	...	...	...	...	...	2	...	...	...	...	4	...	...	...	6	2	...	...	...	...	...	...	...	5	...	...	...	...	13	...
...	...	...	...	...	...	1	...	4	...	...	...	...	5	...	...	...	...	...	18	...	...	7	...	...	...	112	...	...	...	...	137	...
...	...	3	...	...	...	...	...	3	...	...	...	...	6	...	...	...	...	3	8	...	...	...	...	...	...	12	...	...	...	...	23	...
...	8	11	...	...	...	...	...	2	...	...	...	...	21	...	...	...	8	...	1	16	...	...	...	...	...	37	...	...	...	...	62	...
...	...	...	...	...	...	...	...	5	...	...	...	...	5	288	...	...	...	...	1	...	...	...	...	...	...	27	...	...	...	...	28	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...	2	244
...	...	...	...	...	...	...	...	...	...	12	...	...	12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	25	...	...	25	...
...	...	...	...	...	...	...	...	...	...	43	...	...	43	...	...	...	...	...	...	...	...	...	...	...	...	...	...	139	...	...	139	...
...	...	...	...	...	...	...	...	...	...	12	...	...	12	...	...	...	...	...	...	...	...	...	...	...	...	34	...	117	...	...	151	...
...	...	...	...	...	...	...	...	...	...	18	...	...	18	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15	...	...	15	...
...	...	...	...	...	...	...	...	7	...	...	...	...	7	...	...	...	...	...	...	...	...	...	...	...	...	4	...	1	...	...	5	...
...	...	45[illegible]	...	...	...	...	...	...	...	...	...	...	45	...	...	...	...	$82^{62''}$	...	...	...	$8^{74''}$	...	...	...	...	...	...	...	...	90	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1''	...	...	...	...	...	...	...	...	...	...	...	...	1	...
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4	14	63	150	2	1	2	17	315	24	100	4	97	...	804	33	5	18	93	139	20	1	17	9	26	1	490	75	673	4	1,295	...	2,899

Rails broken and taken from track during January, Febr

Compiled by New

NAME OF RAILROAD.	DIVISION.	1905																							
		Year rolled																							Total.
		1904	1903	1902	1901	1900	1899	1898	1897	1896	1895	1894	1893	1892	1891	1890	1889	1888	1887	1886	1883	1881	1880	1879	1872	
Delaware & Hudson.	Susquehanna	30	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	36
— —	Saratoga	12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12
— —	Champlain	12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12
Lehigh Valley.	Main Line	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		See note			125	...
— —	Branches	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rutland.	O. & L. C.	...	...	...	2	2	...	...	...	1	...	...	...	...	1	2	2	...	...	...	...	...	...	...	...	10
—	Chatham	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
New York, New Haven & Hartford Railw. Co.		...	...	...	...	...	...	...	...	...	...	...	...	...	...	7	3	...	...	...	...	...	...	...	...	10
Boston & Maine	Main Line	...	...	2	...	1	...	...	2	...	...	2	1	...	2	1	1	1	3	...	...	...	...	...	...	16
— —	Branches	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	11	...	...	2	3	1	...	18
Buffalo, Rochester & Pittsburg	Rochester	...	...	2	...	2	...	...	4	4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
— — —	Buffalo	1	2	...	...	...	...	...	5	4	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	14
New York, Ontario & Western	Main Line	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— — —	Branches	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pennsylvania (B. & A. V. Division)	Chautauqua	...	...	1	...	22	...	...	67	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9
— (— —)	Buffalo	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
— (— —)	Rochester Branch	...	...	...	...	...	...	...	...	...	6	1	1	1	11	11	3	...	...	...	...	11	5	...	...	5
Lake Shore Railway	Main Line	105	8	...	16	33	26	15	13	1	5	...	3	2	...	...	...	...	...	...	...	...	...	...	...	22
New York Central & Hudson River Railroad.	Main Line Eastern	192	5	1	...	...	2	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20
— — — —	— Mohawk	6	9	21	21	43	3	...	...	...	...	1	...	2	1	2	...	...	...	...	...	...	...	...	...	10
— — — —	— Western	1	14	7	33	14	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	7
— — — —	Branches Eastern	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	
— — — —	— Mohawk	...	...	...	1	...	...	...	...	7	...	2	2	1	3	10	...	...	...	...	7	...	...	...	...	33
— — — —	— Western	...	...	...	...	...	...	1	2	...	...	...	1	...	...	...	...	...	...	1	2	...	...	...	1	9
— — — —	— R. W. & O.	3	1	...	...	3	...	...	1	2	...	...	...	...	4	3	...	5	...	...	...	...	...	...	...	2
— — — —	— River Division	6	...	...	2	2	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
— — — —	— Pennsylvania Division.	...	...	...	...	...	1	...	1	1	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	
Erie	Main Line New York	...	1	1	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
—	— Delaware	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
—	— Susquehanna	...	6	2	...	9	7	2	...	1	...	1	16	1	8	2	...	...	...	...	...	...	...	...	...	5
—	— Allegheny	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
—	— Buffalo	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	
—	Branch Rochester	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
—	— Greenwood Lake	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
—	— Goshen & Decker Town	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
—	— Buffalo & South Western.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7	2	...	...	...	...	...	...	...	
—	Meadville Division	...	...	...	...	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
	Total.	368	52	38	76	138	43	19	100	21	13	8	25	7	30	41	17	8	15	2	9	13	8	1	1	..

Note : Lehigh Valley.
99 rails in track over 10 years.
16 — 4 to 5 —
4 — 3 to 4 —
2 — 2 to 3 —
3 — 1 to 2 —
1 — 1 year.

rch, 1905, 1906 and 1907, in New York State.

ailroad commissioners.

1906

Year rolled																				Total.	Grand total.
1902	1901	1900	1899	1898	1897	1896	1895	1894	1893	1892	1891	1890	1889	1888	1887	1886	1885	1881	1880		
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	32	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	19	60
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	See		50	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	note		...	50
...	2	1	...	...	...	1	...	...	...	...	1	2	...	...	...	...	...	...	...	7	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7
...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	2	2
1	2	2	...	...	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	7	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7
...	...	...	...	...	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	4
6	...	...	...	...	...	4	2	...	1	...	...	...	...	...	...	...	...	...	...	17	...
...	...	...	...	...	...	...	...	...	...	...	...	1	1	4	...	...	1	...	...	7	24
...	...	...	78	48	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	129	...
11	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	17	...
...	1	...	2	2	3	...	1	...	2	4	7	3	4	1	1	2	...	2	2	40	186
...	4	3	...	3	1	...	1	...	2	...	...	...	...	...	...	...	...	...	...	34	34
...	...	...	1	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	68	...
48	10	25	2	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	116	...
2	10	15	...	...	1	...	1	3	...	4	...	1	...	...	...	...	...	...	...	63	...
...	...	...	1	...	...	...	...	...	...	...	...	3	...	...	...	...	...	...	...	4	...
...	...	2	...	...	...	...	...	...	...	...	2	1	...	...	...	...	...	...	...	5	...
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3	...	1	...	...	...	...	...	...	1	2	4	1	...	3	2	...	3	...	...	21	...
...	2	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	288
1	1	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12	...
7	...	19	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	43	...
...	...	3	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12	...
8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	18	...
...	2	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7	...
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...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	804

te : Lehigh Valley.
40 rails in track over 10 years.
4 — 4 to 5 —
2 — 3 to 4 —
3 — 2 to 3 —
1 — 1 year.

1907

Year rolled																													Total.	Grand total.
1906	1905	1904	1903	1902	1901	1900	1899	1898	1897	1896	1895	1894	1893	1892	1891	1890	1889	1888	1886	1885	1884	1883	1882	1881	1880	1874	1873	...		
64	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	64	...
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...
26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	26	93
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	See		103	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	note		...	103
...	...	...	...	...	...	4	1	1	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	7	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	11	...	13	20
3	23	...	...	...	...	...	...	...	...	...	1	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	29	29
...	1	...	...	...	...	...	1	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5
119	4	1	...	...	...	...	...	2	1	1	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	132	...
120	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	124	256
...	...	1	2	...	...	...	3	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	2	10
1	5	...	2	1	...	4	73	13	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	105	...
4^{07} 13^{06}	6	19	3	10	5	3	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	64	...
...	...	...	1	...	...	...	...	1	1	...	4	1	7	3	2	4	1	...	...	1	...	2	1	4	3	...	...	...	36	205
176	319	...	...	...	1	3	...	2	...	...	...	...	1	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	505	505
...	13	442	12	3	...	...	...	...	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	477	...
50	144	30	34	47	5	21	3	...	...	...	...	1	...	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	338	...
32	76	5	9	6	4	27	2	...	...	...	1	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	164	...
...	...	...	1	...	1	...	...	...	3	...	...	...	...	...	...	2	...	...	2	...	3	...	...	1	...	...	...	...	13	...
53	...	1	...	7	3	16	5	...	10	3	2	2	1	3	9	17	...	...	...	...	1	4	...	...	...	...	...	...	137	...
4	...	...	...	1	1	1	...	2	3	...	...	...	4	...	...	...	1	...	...	...	1	4	...	...	...	1	...	...	23	...
15	7	14	2	2	1	...	3	...	2	...	1	...	4	1	...	3	...	2	2	1	...	1	1	...	...	...	...	...	62	...
...	...	3	2	1	7	9	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	28	...
1	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1,244
8	7	3	...	1	...	3	1	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	25	...
125	...	8	...	...	...	3	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	139	...
19	80	9	...	...	...	5	4	1	1	1	...	...	22	...	1	8	...	...	...	...	...	...	...	...	...	...	...	...	151	...
4	...	5	4	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15	...
...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	4	...	...	...	...	...	...	...	...	...	...	...	...	5	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8	2	1	...	...	...	...	1	7	...	...	71	90	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	1	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	429
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2,899

Note : Lehigh Valley.
74 rails in track over 10 years.
6 — 5 to 7 —
10 — 4 to 5 —
3 — 3 to 4 —
7 — 2 to 3 —
2 — 1 to 2 —
1 — 1 year.

quite recently, been kept in such shape as to render statistics on the question of the breakage of rails accurate or reliable, and consequently in speaking of this matter, I can only give you impressions and not substantiated facts. These impressions, however, are confirmed to a very large extent by conversations with the officers of other railroads, who, as a general rule, agreed that the breakages of steel rails during the last four or five years have become much more numerous than formerly, and may be properly described as excessive.

" I do not think these breakages can be ascribed to any one cause, but rather to the cumulative effect of a number of causes acting together. Prominent among these, perhaps, is the modern tendency to insist upon constantly increasing the output of tonnage from a given plant. This involves, of course, higher speed being attained in the various processes of manufacture. This means, of course, that less time is consumed in the transformation of the steel from the ingot to the bloom and from the bloom to the rail, which is practically now one continuous process, where it used to consist of two or three separate processes. It also has the effect of considerably increasing the temperature at which the metal is worked, and this in turn is apt to produce somewhat less dense and homogeneous product. Forging steel at temperatures over red heat, as well known to steel experts, is ineffective.

" Another cause which tends to help along these same results, is the increase in the size and weight of the rail sections. It is manifest that in starting from the ingot or bloom of a given size less time and less pressure, or, in other words, less work upon the metal, is necsesary to produce a section weighing 90 or 100 lb. per yard, than would be required to produce a section weighing 50 or 60 lb. per yard, and in this way also, the density and solidity of the metal in the finished rail is apt to be less in the heavier section which we are using to-day, than in the lighter section used years ago. I believe that the section of the heavier rail is just as safe as the lighter section in relation to the loads carried, provided the density of the metal is the same in both cases, and I do not think the section of the heavier rails *per se* is at fault.

" It has been found that a considerable number of the breakages are due to what is technically known as " piped " rails.

" This is a hidden defect which it is impossible to detect by the most careful surface inspection, and I believe can be attributed largely to the desire on the part of manufacturers for increased tonnage product. The process of casting the ingots from which rails are finally made, results necessarily in the upper portion of the ingot being more or less defective by reason of the contraction cavity and the occluded gases contained in small pockets on account of the molten metal being poured into the mould more rapidly than the gases can escape. This is common to all forms of steel castings, and it can be overcome by cutting off and discarding the upper end of the ingot before rolling it into rails. This necessarily involves the wasting of a considerable amount of material, and I think it is very likely, that in order to increase the tonnage and decrease the cost of production, the mills are discarding less of this metal than formerly, with the result that a larger per cent of the finished product contains these defects, which it is impossible to detect until the rails have been subjected to considerable service, and which has the effect of eventually producing a broken rail.

" From what I have said above, I think it will be apparent that an increase in the section of the rail is not likely to cure the difficulty, nor is it necessary as a measure of safety, nor do I believe that the chemical composition of the steel from which rails are made is subject to just criticism.

" There are some measures which I believe could be adopted by the rolling mills which would improve the quality of their product :

" First : A somewhat slower manipulation of the metal, resulting in the finishing of the rails at a lower temperature than is common at present, and to that extent increasing the amount of work or pressure which is applied to the metal, and consequently increasing its density and solidity.

" Second : The discarding of a somewhat larger percentage of metal from the original ingot, which would have the effect of lessening the liability of hidden defects in the finished product.

" This whole matter was gone into very carefully in two papers which I wrote a number of years ago. While I was a good deal less experienced as a railroad man then than I am now, I was fresh from a very close study of the methods of manufacture, which have not materially changed in respect to rails in the last fifteen or eighteen years. The conditions which I cited as bad when I wrote the papers I refer to, have grown somewhat more accentuated, and because a heavier weight of rail is being used, there is actually less mechanical work being done on the steel than was formerly the case."

President.

" We have had more or less broken rails this winter, but we did not seem to have as serious a time as some of the other roads. We have taken no steps to try to get different rails because the steel companies have been unwilling to change specifications, and the railroad companies have been obliged to take the rails as furnished by the steel companies or not get it.

" My own notion is that the breakages are due to two principal causes : Firstly, that the demand on the steel companies for rails is so great that there is not the same care used to-day in making the rails that there used to be ten or twenty years ago; secondly, that the volume of business passing over the railroads has been so great in the last eighteen months, that in spots the track is not as good as it used to be, due to this volume of business and to scarcity of common labor, and the poor quality of common labor.

" As you know, many of the railroads throughout the country are overtaxed as to business, and the result of that is a strain on all departments, which increases the danger of poor work and risk of accident."

President.

" Your letter of April 6. I should say the quality of the rails furnished is gradually getting worse, and the axle load of engines and their speed is gradually increased. Under these conditions, it does not seem surprising to me that the roads should have many broken rails. On our road, we are not having any trouble, because we have stopped at a 45,000-lb. axle load and a moderate speed."

Vice-president.

" Personally, I think a good deal of the trouble with the wearing qualities of the present rails is due to a process of manufacture so rapid that the metal never cools, and the minimum amount of work placed on them until they are turned into finished sections, and think that with concerted action on the part of the railroads and in conjunction with the rail manufacturers that the rail specifications should be made to govern the process of manufacture so as to accomplish a tougher rail and one that is free from pipes. We get rails that stand our specified drop tests and that are in composition according to our specification, but we do not get the wearing properties we should. It has also become a question in connection with the larger rail sections and the heavier loads, whether the time has not arrived when the section of the A. S. C. E. should not be revised so as to distribute the thickness of the flange, web and head to be more uniformly the same throughout so that the heating and cooling would also be more uniform. I believe that the open hearth process is the one that should be generally adopted in the United States as rapidly as possible on account of the possibilities of reducing the phosphorus and sulphur."

RESIDENT-ENGINEER.

" Your favour of the 6th duly received, and I have taken some pains to gather the information you desire from our chief engineer, who states substantially as follows :

" I beg to advise that we have had more trouble during the past three months by rails breaking than at any other time in the past, and our trouble has all been with rails rolled in the summer and fall of 1906.

" One mill furnished us with 3,000 tons of 90-lb. A. S. C. E. section on which we have had only three broken rails. Another mill furnished us during the same period 4,000 tons of the same section rail and we have had several hundred rails broken, the rails breaking principally in the flange. In taking the rail out, in some cases we found the flange broken out at six different places. We have been investigating the matter, but have been unable to arrive at satisfactory conclusions as to the cause. We are still carrying on our investigations.

" We are of the opinion that these breakages are not caused on account of the loads to which these rails have been subjected being carried to extremes. We have used this same rail section and same class of power with 50-ton steel cars for the past three years, and have had but few rails break until the past three months of rails received last summer and fall. We are of the opinion that the trouble lies with the class of Lake Superior ore that is now being used in the manufacture of Bessemer steel for rails, there being too much phosphorus in the same, as by using the Bessemer process too much phosphorus is left in the steel. From indications, the rails have been too severely gagged in straightening at the mills.

" The principal railroads in this neighborhood have had the same trouble with last year's rolling of rails. Increasing the section I do not think would remedy it, as we have had 60 miles of 100-lb. steel, rolled in 1898, which is to-day in the track and giving good service and on which we have very few broken rails."

PRESIDENT.

Figs. 1 to 13. — *Defective 100-lb. rails.*

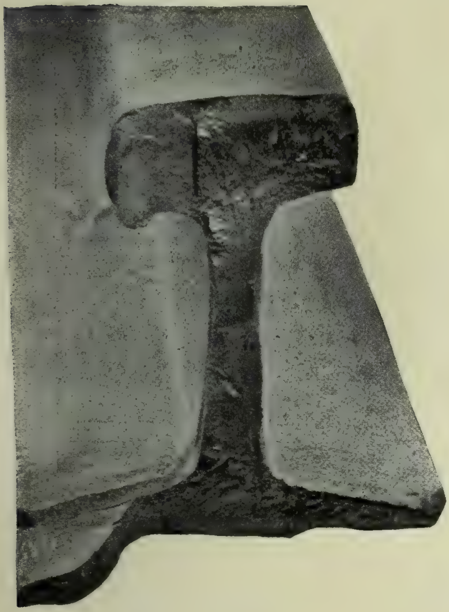


Fig. 1.

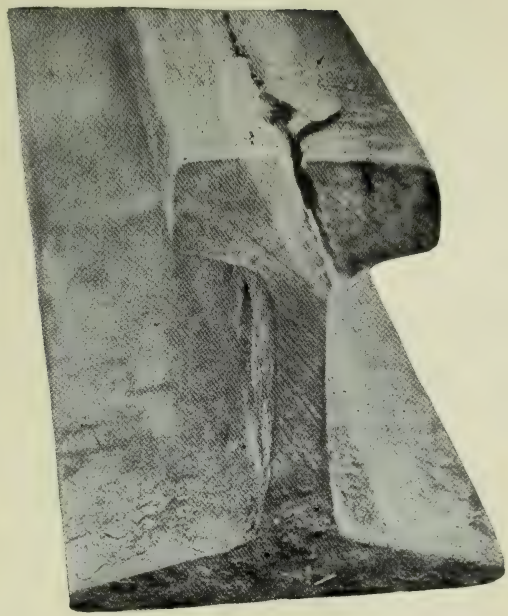


Fig. 2.

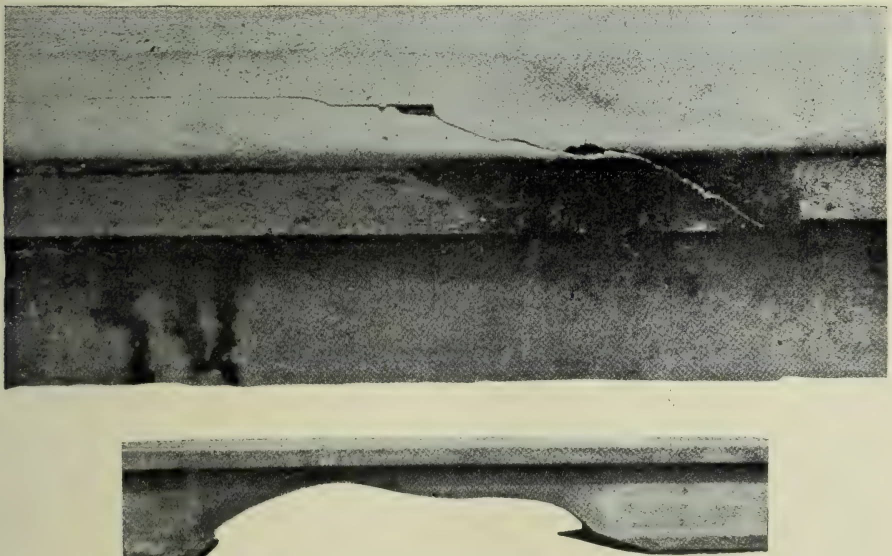


Fig. 3.

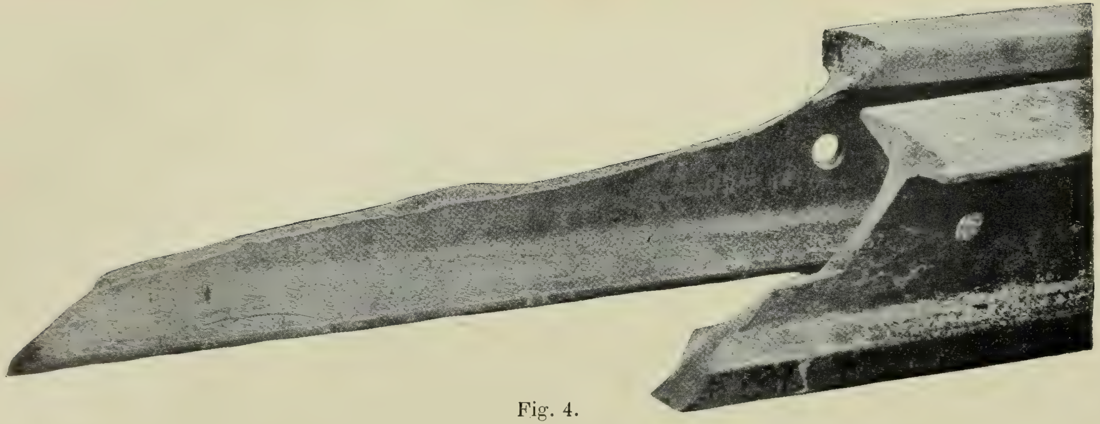


Fig. 4.

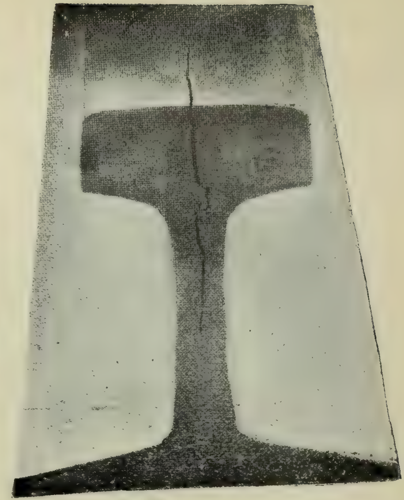


Fig. 5.

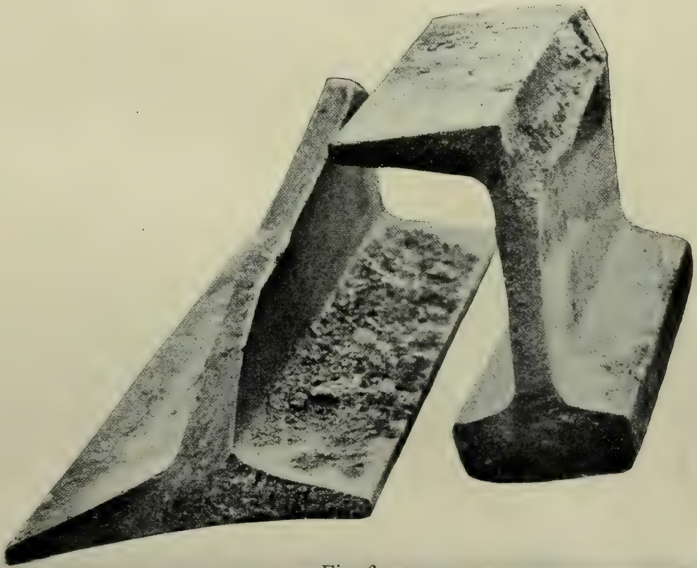


Fig. 6.

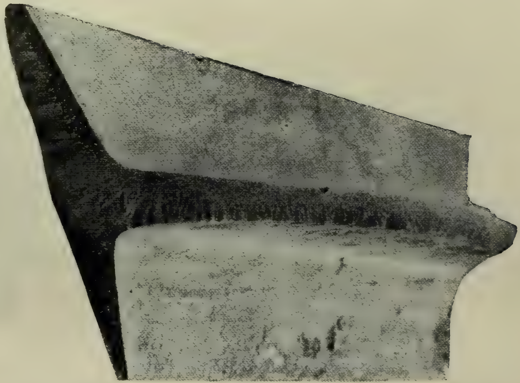


Fig. 7

“ Referring to your communication of April 13 in regard to breakages of steel rails :

“ I attach for your information a memo, showing our record of broken rails during 1906. This statement shows weight of the rail, temperature at time of break, and the date it was laid.

“ Our greatest trouble seems to be with the 90-lb. rail which was laid in 1898, 1899 and 1900, and the chemical analysis of this rail shows improper material used in the making of the rail.

“ We have had these matters up with the manufacturers, however, and naturally there is a dispute about it.

“ I hope this statement will be of use to you in reaching conclusions on this important matter.”

President.

RECORD OF BROKEN RAIL.

MAIN LINE.

	Weight of rail in lb.	Temperature at time of break.	Date laid.
April 14, 1906	90	...	1898
May 1, —	90	...	1900
July 17, —	90	80 above.	1898
July 21, —	100	...	1903
October 16, —	100	60 above.	1903
December 4, —	80	40 —	1895
February 4, 1907	100	4 —	1900
— 4, —	100	4 —	1900
— 7, —	100	35 —	1905
— 8, —	100	...	1902
— 8, —	100	...	1903
— 8, —	100	...	1902
— 17, —	100	...	1902
April 11, —	76	...	1893
— 11, —	56	...	1897
— 14, —	75	46 above.	1892

“ *A* ” *Division.*

	Weight of rail in lb.	Temperature at time of break.	Date laid.
April 30, 1906	90	...	1899
May 21, —	90	70 above.	1900
July 6, —	90	65 —	1900
— 6, —	90	65 —	1900
— 20, —	90	75 —	1905
August 27, —	90	65 —	1900
September 15, —	90	60 —	1900
— 19, —	90	75 —	1900
October 16, —	90	60 —	1898
— 25, —	90	65 —	1900
— 27, —	90	65 —	1900
— 30, —	90	60 —	1902

	Weight of rail in lb.	Temperature at time of break.	Date laid.
November 1, 1906	90	50 above.	1900
— 2, —	90	60 —	1898
— 6, —	90	60 —	1900
December 4, —	80	8 —	1893
— 4, —	90	10 —	1900
— 11, —	90	45 —	1900
January 6, 1907	90	50 —	1899
— 7, —	90	60 —	1899
February 9, —	90	30 —	1900
— 9, —	90	30 —	1900
— 16, —	90	35 —	1900
— 20, —	90	40 —	1900
— 20, —	90	40 —	1900
— 23, —	90	25 —	1900
— 26, —	100	30 —	1901
— 27, —	90	40 —	1900
March 5, —	90	35 —	1900
— 14, —	90	45 —	1900
— 16, —	90	55 —	1900
— 18, —	90	50 —	1905
— 19, —	62 1/2	40 —	1895
— 19, —	62 1/2	...	1895
— 19, —	70	...	...
— 19, —	56	...	Old.
— 21, —	90	50 above.	1905
— 23, —	56	70 —	Old.
— 23, —	56	70 —	—
— 31, —	90	50 —	1899
April 2, —	62 1/2	...	Old.
— 11, —	90	50 above.	1900

MAIN LINE.

June 11, 1906	80	50 above.	1906

“ A ” Division.

June 5, 1906	100	75 above.	1903
November 2, —	90	55 —	1900
— 16, —	100	70 —	1903
December 10, —	100	40 —	1903

“ B ” Division.

August 6, 1906	80	88 above.	1905
November 17, —	80	50 —	1905

“ C ” Branch.

February 8, 1907	80	...	1905
— 23, —	80	...	1905
March 12, —	80	...	1898
April 4, —	80	45 above.	1905

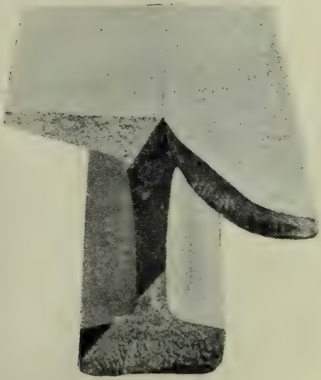


Fig. 8.

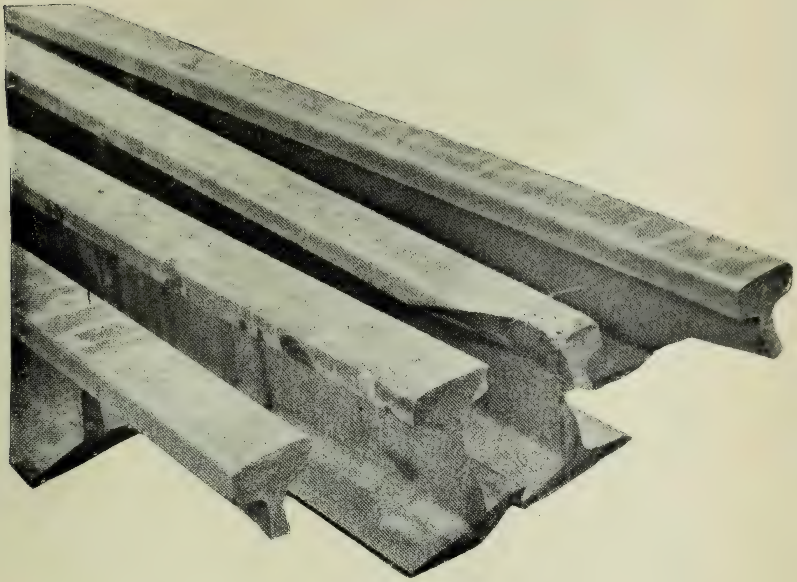


Fig. 9.

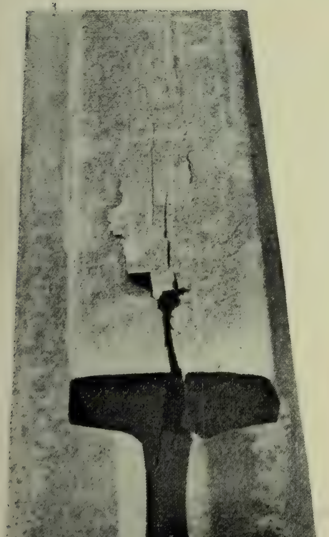


Fig. 10.

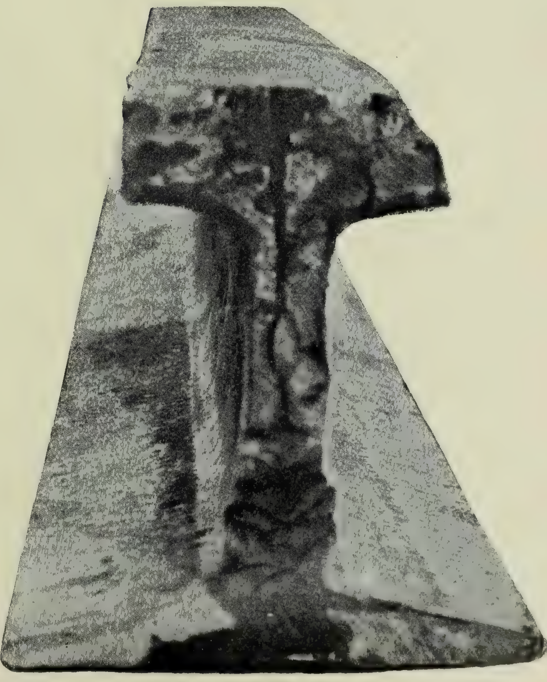


Fig. 11.

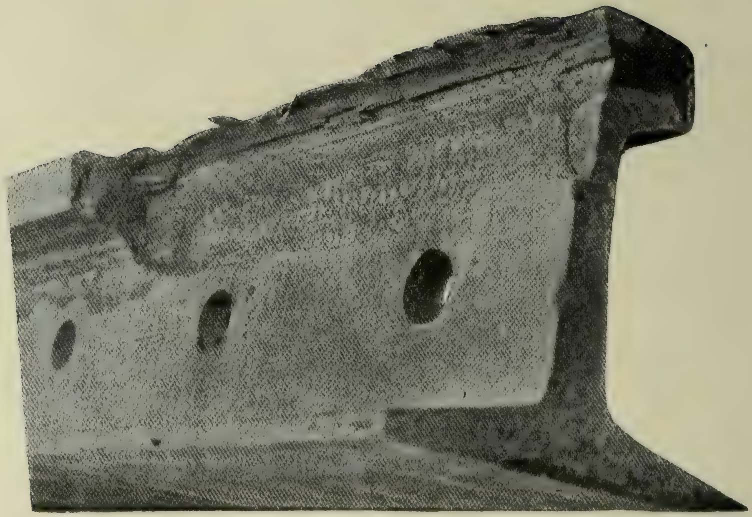


Fig. 12.

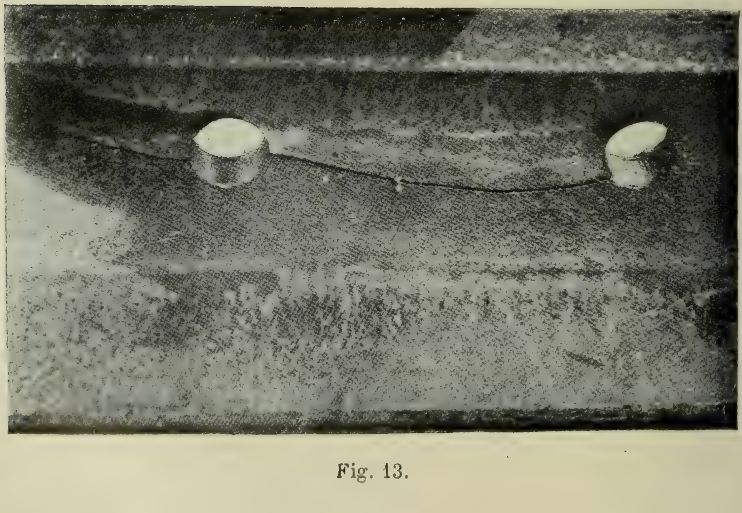


Fig. 13.

“D” Branch.

		Weight of rail in lb.	Temperature at time of break.	Date laid.
March	1, 1907	80	10 above.	4 days.
April	11, —	80	50 —	1905
	MISCELLANEOUS.			
March	19, 1907	56	...	Old.
—	24, —	80	35 above.	12 hours.
—	25, —	80	60 —	1906

“Reference to our records discloses the following cases of broken rail occurring on this line during the year 1906 :

“On 190 miles of 60-lb. steel laid between 1890 and 1893, and 16 miles laid in 1898, there were 38 rails broken during the first six months of the year, thirty-two being in cold weather and six in warm weather.

“On 38 miles of 75-lb. rail laid in 1899, there were 45 rails broken during the year. Twelve of these were broken in warm weather and thirty-two in cold weather, and one on account of having been kinked by fire.

“On 70 miles of 80-lb. rail laid between 1902 and 1905, there were seven rails broken during the year; one during cold weather and six during warm weather.

“On 248 miles of 85-lb. rail laid during 1906, there were seventeen (17) rails broken during the year, five during cold weather and twelve during warm weather.

“The above is summarized as follows :

Weight.		Age.	Broken rails, per mile per year.
60-lb.	190 miles	15 years.	...
...	16 —	9 —	0·37
75-lb.	38 —	7 —	1·18
80-lb.	70 —	1·5 —	0·10
85-lb.	248 —	6 months.	0·20

“Considering the number of years the 60-lb. rail has been laid, the broken rails per mile per year seems to average much less than in any of the heavier sections, disproving the theory that the rails are subjected to heavier tonnage than they can carry with safety, and would seem to give strength to the contention that the rails which are now being furnished are of an inferior quality compared with those rolled 12 or 15 years ago.

“The cause of the inferior modern rail has been the subject of a great deal of discussion — two theories being advanced : one — which is generally accepted as correct — being that in the process of manufacture the rails leave the rolls at too high a temperature. The other theory is that interior strains are developed in the larger sections, which do not occur to as great an extent in the rolling of lighter rails.

“We are inclined to agree that the high temperature theory is the correct one. A number of the roads are endeavoring to limit the temperature of the rails as they leave the rolls, but I am without any definite knowledge as to in what degree this has been effectual in preventing breakages.”

PRESIDENT.

"I beg to say that the experience of this company is that we have had more broken rails during the past winter than heretofore.

"I am inclined to think that rails rolled during the last few years are not so good in quality as those rolled ten or more years ago. We have had breakages of rails made by many different manufacturers, and of many different dates or ages. Possibly a considerable part of the increased breakage is due to heavier traffic and greater proportion of heavy engines than heretofore. On one line upon which heavier engines were placed about two years ago, the breakages were very numerous. Piped rails, which did not show up the defects under the lighter engines, were quickly discovered after the new and heavy engines were placed in service. Negotiations are pending for some change in specifications, but mills seem to be very averse to meeting the wishes of purchasers in this respect."

CHIEF ENGINEER.

"We seem to be immune in a measure from the general complaint relative to broken rail. During the past season, we had 148 90-lb. rails break on approximately 1,500 miles of track laid with this type of rail; only eleven of these rails were rolled in 1905 and 1906, the balance run from 1898 and so on up. The greatest majority of these breakages were due to flaws and a few of them, in my judgment, to improper care. As you probably know, our freight power is comparatively light, the maximum being 128,000 lb. on the drivers.

"We can scarcely hazard an opinion as to the underlying cause of the trouble on other lines, because we are not acquainted with the conditions, and the difficulty on our own road is no greater this year than it has been for a long period of years with lighter rail."

VICE-PRESIDENT.

"There was an increase during 1906 in both the total of defective and broken rails removed from track, and in the number of defective and broken rails removed per 100 miles of track. The ratio of increase of defects and breakages in 100-lb. rail was greatly in excess of that of the 85-lb. rail.

"Our engineers have been giving the question much investigation and consideration, but do not feel prepared at present to express their conclusions as to the underlying cause of the trouble. We understand the whole subject will be a matter of discussion at the coming meeting of the American Railway Association, when no doubt much additional light will be thrown on it."

PRESIDENT.

"Our investigations in connection with rail failures indicate that the cause of 90 per cent of the failures is due to mechanical defects or lines of weakness in the flange, which become apparent after the break occurs in the form of a slight fold in the base of the rail.

"We are receiving rails from one mill in which 80-lb. rails pass through the rolls twenty-eight times. The breakages in this class of rail are very much less than those of any other brand of 80-lb. rails, and the phosphorus in these rails does not exceed 0·085 per cent and the carbon average 0·57 to 0·59 per cent. This result leads us to think that the proper remedy for rail breakages is to reduce the phosphorus and other impurities, and to give a larger number of passes through the rolls, with the carbon high enough to prevent the ends of the rails from flattening."

VICE-PRESIDENT.

" We certainly have had the same experience as other roads, and have been troubled especially with defects in the ball of the rail appearing suddenly after the rail has been in service but a short time. In some cases, these flaws are so bad that it is necessary to change the rail very promptly to avoid serious danger.

" Our idea is that in the haste to increase product and the good market which has prevailed, that the former care is not exercised and that the ends of blooms are not as conscientiously cut off as formerly, thus causing the piping in the interior of the rail, which develops under road conditions."

GENERAL MANAGER.

" Our figures show, eliminating breakages that were due to the broken rail being practically worn out, we have had but 307 broken rails in the main tracks of our line during the four months ending March 31 last.

" We have on our lines equal to 1,470 miles of single main track, which would show that we have had to remove but one broken rail from every 4 $^3/_5$ miles of single track, which with the very large traffic we have over the greater portion of our lines is, as we think, not an unduly large number of broken rails to have had on our lines.

" The chief trouble we find with the rails we have been getting in recent years, is that we are not getting the wear out of them we should. We have endeavored to correct this trouble by asking the steel company from whom we buy most of our rails, to furnish us a rail higher in carbon, but they have been unwilling to do this, apparently fearing that the rails would be made more brittle should they use a greater percentage of carbon in them.

" As to the rail we are getting for 1907 delivery, we have arranged through our rail inspector to have the rails held a little longer before they go through the rolls on their final passage, the idea being by this means to get better wear out of them and a somewhat tougher rail, due to the last rolling being at a lower temperature.

" We have been experimenting in a small way with some open hearth rail we got several years ago from the Tennessee Coal & Iron Company and we are quite favorably impressed with the comparative results we have gotten from the use of this open hearth rail as compared with the Bessemer of the same weight, laid where it has had the same wear as the open hearth rail. As soon as we can get concerns here in the East to furnish us any quantity of open hearth rail, we are going to use it more extensively.

" The opinion of our people seems to be that the inferior quality of Bessemer rail which we have been getting recently, has been due to two causes : One is that the ores which can be manufactured by the Bessemer process and have given a good wearing rail, are growing scarcer, and the ore is of a poorer quality and that with these ores a better rail can be produced by treatment with the open hearth process than by the Bessemer. We think, furthermore, that to some extent the poor quality of rail we are now getting is due to the fabrication of it and that the great endeavor of the rail makers of recent years has been to turn out a large tonnage and that in doing this the rail is rolled hotter and without as many passes through the rolls as in former years, and, as result, the metal in the finished rail is not as tough or strong as that in the rails formerly furnished by the steel rail makers.

" Prior to about 1901, the different companies making rails in the United States gave certain guarantees as to the quality and wear of their rails. Since about that time, no contracts can be obtained with any of the rail makers of this country giving any guarantees whatever as to the wearing qualities of the rail furnished. As a rule, they will not go further than to replace such rails as in service are broken and show actual flaws in the individual rails. There can be no question but what since the provisions referred to in the old rails contracts have been eliminated, the quality of rail furnished has deteriorated.

" Several years ago, we increased our standard rail from 80 to 90 lb. per yard. This with a view of better providing for our increased traffic and the increased weight of our motive power and equipment. At the time we decided to increase our standard weight of rail from 80 to 90 lb., we investigated the question of whether we would go from 80 to 100 lb. rails, but as result of our investigation of the matter and a trial of some 100-lb. rails, we found that the lines using this heavier rail, were not getting sufficient additional wear from it to warrant the increased cost of same. We also found that as a result of our trial of the 100-lb. rail laid right alongside 90-lb. rail, the 100-lb. gave no better wear under the same traffic condition than the 90-lb. In fact, the 100-lb. rail showed greater wear than the 90. This seemed to demonstrate that the heavier the rail, the poorer the material in it. I think this is the result of the experience of other companies so far as we have been able to ascertain."

President.

" There is no question that breakages or rails, rolled in the last few years, have been more numerous than those previously rolled. We have had a great many 80-lb. rails broken that have been rolled in the past five years. In 1904, we had removed 778 broken rails that had failed in track, manufactured by the X mill and the Z mill. Most of the X rails failed through what is known as piping, and the Z rails through flange breaking. We have also had a very large amount of broken rails manufactured by the B Steel Company. These have broken in different manners; some being badly piped while others have just broken square off, through some defects.

" In the fall of 1903, we started to buy 100-lb. rails. The records of the B Steel Company show quite badly, as to breaking of their 100-lb. rail that we got in the early rolling, but in the last rolling, that is to say in 1905, the record is not so bad. The rails they furnished us in 1904 seem to be the worst.

" The rails we received from the Q Steel Company, previous to 1906, gave very good results, in fact, were the best rails we have purchased in recent years. But, we have had a great many broken rails from their 1906 rolling. It is my opinion that one of the greatest troubles with rails we receive to-day, is that the demand is so great that every particle of steel is used that will make a rail, without showing any defects on the surface. This seems to be especially true with the Q Steel Company's rail of 1906 rolling. Previous so that time, the demand for their rails was not so great. They have small converters that will only convert about 4 1/2 tons or iron into steel at one blow. Their ingots being large and converters being small, it gives them a better chance to pour more slowly with an opportunity for the gases to escape during the pouring. Last year they began to press their output, and it is a marked coincidence that as soon as they started to shove their mill and advertised their increased output, their rails became more defective.

" I think one of the greatest troubles with rails to-day is that too much steel is tried to be forced into the rail; in other words, they do not crop their ingots sufficiently to insure that all silicon and other impurities, which are lighter and rise to the top of the ingot, are cut off before the ingots are sent to the blooming and rolling mills. The chemical composition of our rails seems to be rather satisfactory. We do not have any trouble from excessive wear of flange in the head, which shows that our rails are not too soft. Of course, our curvature is light on the main line, and we have not been troubled nearly as much as some roads with heavier curvature as regards flange wearing.

" In the fall of 1903, we laid B rails on a 6° curve, and last year had to replace them owing to their having been badly worn in the side of the head from flange wearing. That gives a life of about three years to that rail in main track. At no other point has it been necessary to replace rails, on account of the flange wear, although some of our curves are 3°, and one or two of them 4 1/2.

" I am sure that if the mills would agree to crop their ingots more, we would have very much better results. I know there are a great many people that argue that 100 lb. is too large a section out of which to make a perfect rail, as compared with the 80-lb., but our experience has been that 80-lb. rails of recent manufacture, that is to say, within the last four or five years, have failed just as readily as 100-lb. rails. It is the practice to give 100-lb. rails almost as many passes as 80-lb. rails get.

" We are now tabulating our list of broken rails, with the object of taking it up with the manufacturers to see whether we cannot make some arrangements by which they will give us a better quality of rail, and incidentally to have replaced the broken rails. The only manufacturers that we have a written guarantee from is the Q Steel Company, although the mills that we have taken the matter up with have always been willing to replace broken and defective rails."

CHIEF ENGINEER.

" I beg to attach hereto a statement of the 85-lb. rails broken from January 1, 1906, to April 1, 1907, inclusive. The breakage of rails which we have sustained does not seem to been caused by severe weather conditions or defective output of any particular mill.

" It is the opinion of our engineering department, that the rails as manufactured at the present time are of inferior quality to those which were rolled several years ago, and that they are subjected to such heavy loads that the least flaw or defect of any kind in the rail will cause it to break — the result of the continual hammering that it receives under our heavy traffic.

" The manufacturers in all cases replace the broken rails with new rail where any flaws are found in the section. We believe that our present rail is too light for the heavy wear to which it is subjected, especially where we do not have sufficient ballast to hold the track to perfect line and surface. If the ballast conditions were perfect, 85-lb. rail would probably answer all purposes, but this condition exists on very few roads."

GENERAL MANAGER.

Statement of 85 lb. broken rail, January 1, 1906, to April 1, 1907. — All divisions.

Track.	Weight of rail in lb.	Age.		Cause.
		Years.	Months.	
Main.	85	...	7	Flaw in center of rail.
—	85	...	7	— —
—	85	...	7	Unknown.
—	85	Not known.		—
—	85	Not known.		—
—	85	1	5	Cracked in flange.
—	85	3	10	Flaw in rail.
—	85	4	...	Unknown.
—	85	2	4	—
—	85	3	2	—
—	85	1	6	—
—	85	3	6	—
—	85	2	...	—
—	85	...	2	Split in center of ball.
—	85	1	5	Rail cracked admitting frost.
—	85	2	5	Soft ties.
—	85	1	6	Cold weather.
—	85	3	5	Flaw in rail.
—	85	2	2	—
—	85	1	4	—
—	85	3	3	Unknown.
—	85	2	3	—
—	85	...	2	Flaw in rail.
—	85	Not known.		— in ball.
—	85	...	2	— in rail.
—	85	...	2	— in ball and web.
—	85	...	2	— in base of rail.
—	85	2	6	— in flange.
—	85	Not known.		Unknown.
—	85	2	10	Poor quality of rail.
—	85	3	1	Flaw in rail.
—	85	2	...	Unknown.
—	85	2	1	—
—	85	2	8	Flaw in rail.
—	85	3	7	Worn.

" Our experience has been that of other lines, that during the past year rails recently put in track have broken in unusual numbers and we are still investigating with a view to ascertaining the cause and applying a remedy. The fact that the breakage occurs most frequently in the rail recently rolled which on our line is of a heavier section than we heretofore laid, indicates that it is not caused by heavy traffic of large engines. On the other hand, when these rails were rolled they were inspected carefully and the analysis indicated the metal to be of first quality.

" The conclusion to which all of this points is that they were not properly worked at the mills, but put on the market with too few rollings.

" I do not state this as a fact, but merely suggest that our experience and investigations up to this time tend to show that such is the case. "

VICE-PRESIDENT.

[385. (07.2 & 621 .131.3]

LOCOMOTIVE TESTING PLANT OF THE PENNSYLVANIA RAILROAD AT ALTOONA.

Figs. 1 to 8, pp. 893 to 899.

(*The Railway and Engineering Review.*)

Since November 19, 1906, the locomotive testing plant at Altoona has been in continuous operation, and the force of 16 men have made on an average about three complete tests each week. Certain portions of the apparatus were temporarily installed at the Louisiana Purchase Exposition and experience gained through operations there, has been embodied in the plant at Altoona. (*See* special " World's Fair " issue of the *Railway and Engineering Review* for December 31, 1904, p. 1051.)

A separate building of steel and brick has been erected for housing the apparatus. The general appearance of the building is shown in figures 1, 2, 3 and 4, which also indicate clearly the coal handling arrangement outside of it, with the bin for ashes directly over the track used for bringing in coal.

The arrangement of the plant is well known, but in this permanent building the floor of the laboratory is on the track level and is made in sections which can be removed by the travelling crane. The space between the removable floor is used for storing absorption brakes, supporting wheels and other parts when not in use. On the same level as the storage space and below the main floor, is all the apparatus for water supply used in controlling the brakes. The driving wheels of the locomotive under test rest upon supporting wheels (20), figure 4, with rims shaped to correspond with the head of the rail. The axles of these supporting wheels are extended and carry absorption brakes (21). The turning of the driving wheels causes the supporting wheels to revolve, but these are retarded to any extent desired. The work actually done by the locomotive consists in overcoming the friction resistance of the supporting wheels and brakes, the resulting force exerted at the drawbar being measured by a traction dynamometer. The axles of the supporting wheels run in heavy pedestals (22) secured to cast iron bed plates (23) resting upon a concrete foundation. There are two bed plates running parallel with the track, and in order that the supporting wheels may be directly beneath the locomotive drivers, these bed plates are provided with T slots, so that the pedestals can be moved along parallel to the track and secured in any position to suit the particular engine under test. The only wheels of the locomotive which move during a test are the drivers. The wheels of the leading truck rest upon rails secured to I-beams and supported upon the same bed plates which carry the pedestals, as shown in figure 2. The wheels of the trailing truck rest upon supporting wheels (which remain stationary during the test) and are carried by pedestals secured to the longitudinal bed plates.

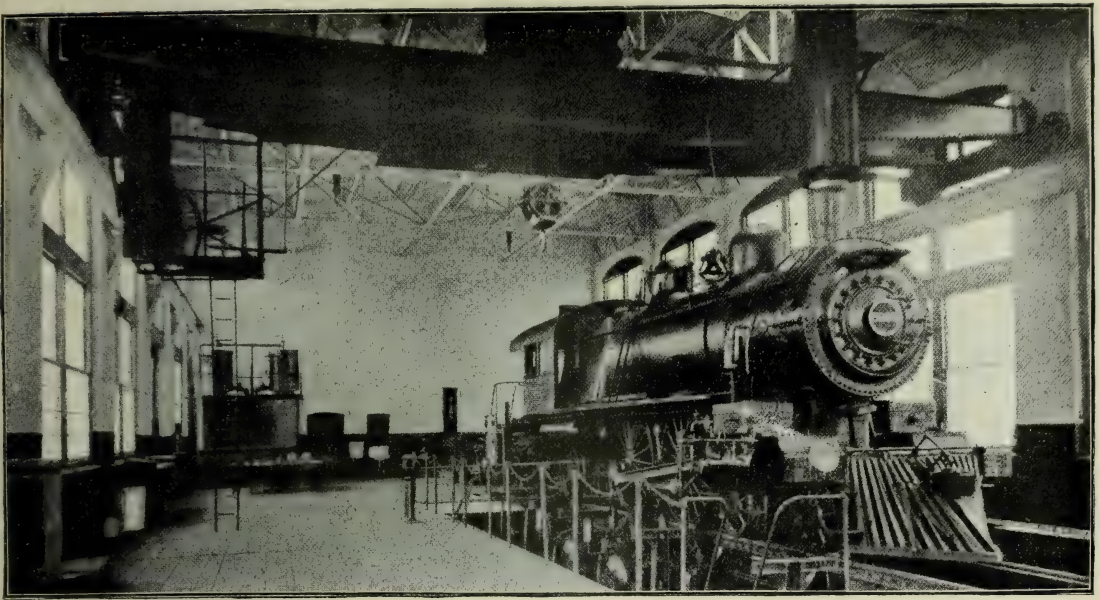


Fig. 1. — General interior view of Altoona locomotive testing plant, Pennsylvania Railroad.

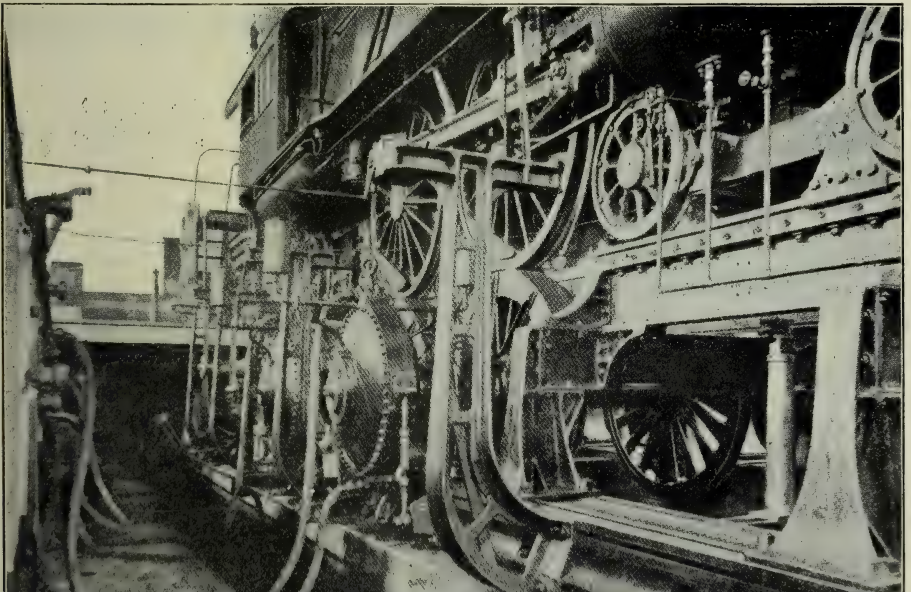


Fig. 2. — View in pit.

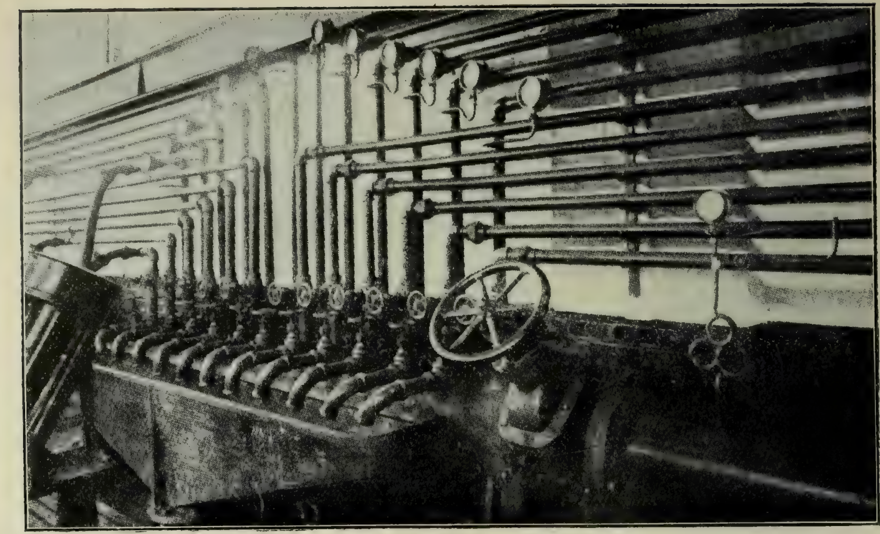


Fig. 3. — Adjusting discharge pipes of Alden absorption brakes.

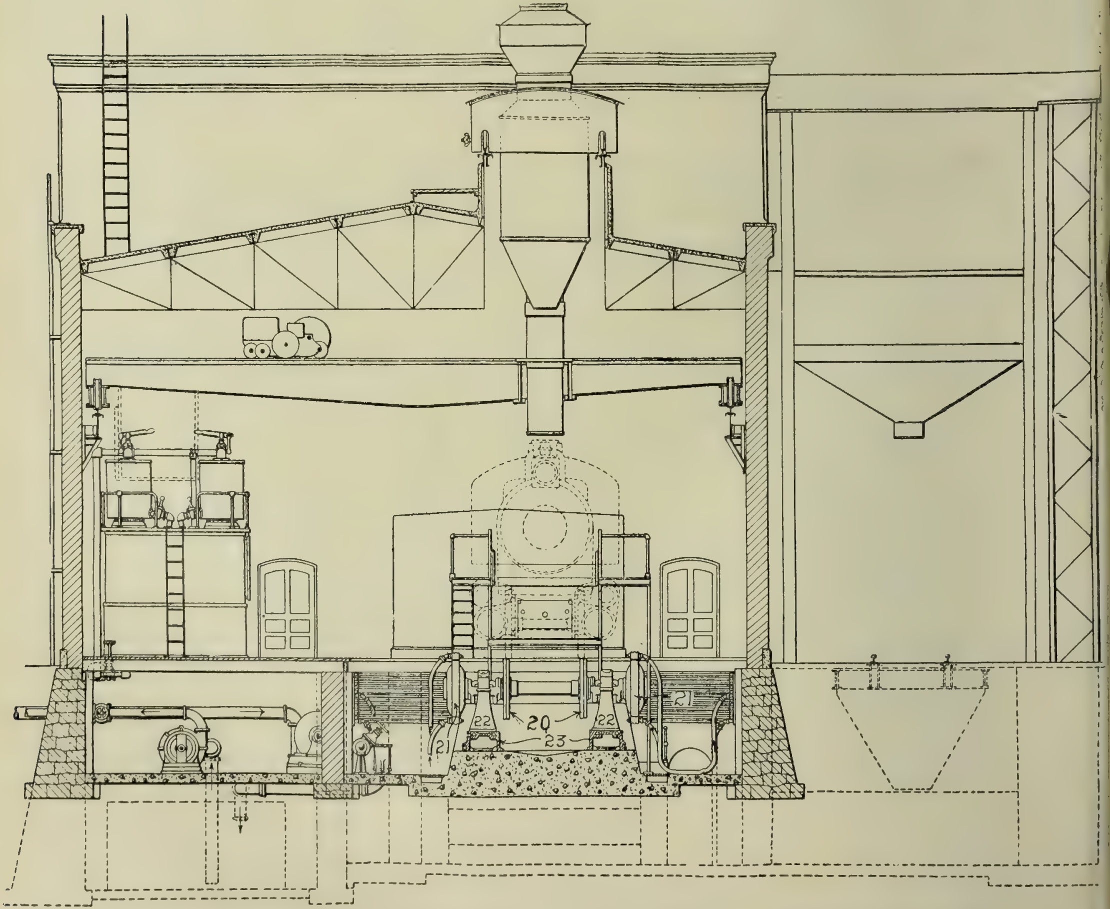
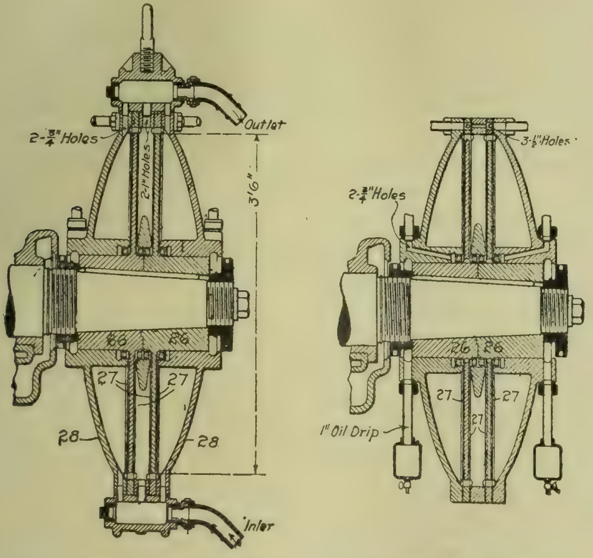


Fig. 4. — Transverse section of Altoona locomotive testing plant, Pennsylvania Railroad.

When preparing the plant to receive a locomotive, the pedestals are carefully bolted to the bed plates, and so spaced that there will be a pair of supporting wheels directly beneath each pair of drivers of the locomotive. A section of special rail is next bolted to the inside faces of the supporting wheels. This rail is composed of a heavy I-beam, to the top of which is secured a grooved head in which the flanges of the drivers run. The tops of the supporting wheels are in line with the track entering the building, so that a locomotive can be backed in and the drivers will run on their flanges until in position directly over their supporting wheels. After a locomotive has been secured in place and its drawbar attached to the dynamometer, these grooved rails upon which it ran in are removed, leaving the drivers resting upon the supporting wheels.



Section showing water connection. Section showing oil connection.

Fig. 5. — Alden absorption brake.

The axle for each pair of supporting wheels carries upon each of its over-hung ends an Alden absorption brake (21). Referring to figure 5, each of these brakes consist of two smooth circular cast iron disks, keyed to the supporting wheel axle. On each side of each one of these disks is a thin, copper diaphragm (27) secured at its periphery, and also at its inner edge to a hooding (28) which does not revolve and has its bearings upon the hubs of the circular revolving disks. The stationary hooding is so designed that when it is filled with water under pressure, the copper disks are forced against the revolving disks, creating friction. Provision is made for securing continuous and uniform lubrication of the surfaces of these revolving disks, and the water is caused to flow through the housing in order to carry away the heat generated. The water thus performs two functions; first, in supplying pressure to cause the friction, and second, in carrying away the heat generated by the friction.

Each brake is connected with the source of water supply by a flexible hose. It is also connected with the discharge pipes by another flexible hose. The discharge pipes for all the brakes empty into an iron trough shown in figure 3 and each pipe is provided with a valve located adjacent to the valve in the supply pipe for the same brake. In placing the load upon the locomotive, these valves are adjusted until the individual brakes each absorb their share of the work. After this preliminary adjustment has been secured, the power absorbed by all of the brakes may be increased or decreased by operating a large valve in the supply main.

In order to secure water under uniform pressure for use in the brakes, a special system has been installed. An elevated tank is located near the testing plant building, and a two-stage centrifugal pump driven by a 75 horse-power electric motor, delivers the water under a constant pressure of 75 pounds per square inch to the main header, from which branch the pipes leading to the individual brakes. The water discharged from the brakes empties into the iron trough shown in figure 3, and from there runs by gravity into a tank located beneath the floor of the building. Water from this intermediate tank is forced back into the outside supply tank by a centrifugal pump driven by a 20 horse-power electric motor. The outside supply tank is regularly used by locomotives going to and from a roundhouse in the vicinity, so that the warm water returning to the tank from the testing plant is not wasted and does not increase the temperature of the water to an appreciable extent. The entire water system is designed to permit of supplying a large volume of water at low pressure when running high speed test and the apparatus is capable of delivering 900 gallons of water per minute.

The locomotive is connected to the dynamometer by an adjustable drawbar, and the dynamometer housing is provided with means for raising and lowering the dynamometer proper to bring this drawbar truly horizontal for various heights of locomotive drawbar attachments in the tailpiece, varying from 30 to 42 inches above the track. To decrease the vibration transmitted to the dynamometer through the drawbar, the two safety bars are provided between the locomotive and the dynamometer frame. At their ends, these bars have universal joints to insure perfect freedom of adjustment, and each bar is provided with an oil dash pot near the dynamometer end. The dash pots are in the form of double disks ground to fit their cylinders closely, and supplied with oil from founts. Their resistance to motion is adjustable by means of by-pass valves in their castings.

The traction dynamometer, which measures the drawbar pull of the locomotive is of the lever type. Referring to figure 6, the weighing mechanism is supported by a frame (32) which slides up and down in ways formed by the housings (33). These housings are very massive, rigidly secured together and anchored to a heavy foundation. The lever system is constructed upon the Emery principle in which flexible steel fulcrum plates take the place of knife edges used in ordinary scales. As the levers are vertical instead of horizontal, their weight would not come upon the flexible fulcrum plates in the direction in which they transmit pressure. It has, therefore, been necessary in certain cases, to supply two fulcrum plates with their axes at right angles, one for carrying the weight of the levers, and the other for transmitting the thrust. Figure 7 shows this arrangement.

This last illustration also shows the lever arrangement. The drawbar is shown on the right. At its end it is provided with a ball and socket joint (fig. 6) to accommodate some slight motion of the engine when running. The weight of the drawbar is taken upon two flexible steel plates and its alignment is secured by flexible rods which provide for its motion without friction. At its end the drawbar is provided with a yoke, which surrounds the weighing levers and is connected to levers (34) and (35), figure 7, by two Emery fulcrum plates. Levers 34 and 35 are duplicates operating in reverse directions, and so arranged that either a pull of thrust delivered by the drawbar can be weighed by the dynamometer. Assume that the locomotive is running ahead and that the drawbar is transmitting its pull to lever 35 which is carried by fulcrum plate 36. The load is transmitted from lever 35 to lever 37 through the link 38 provided with fulcrum plates at each end. Lever 37 is supported by fulcrum plate 39 and its motion is resisted by the calibrated flat spring (40). The thrust of lever 37 is transmitted to lever 41 (which is its duplicate, but works in the reverse direction) through the element 42, so that lever 41 moves in exact accordance with lever 37 and its motion is resisted by the calibrated spring (43). Had the locomotive been running backward and the load delivered by the drawbar been a thrust instead of a pull, lever (34) would have acted instead of lever (35), but the result would have been the same. The oscillating motion of the lower ends of the levers (37) and (41) is transformed into rotary motion of a vertical tube (44 in right detail) by means of steel belts wrapped about a drum on the bottom of this vertical tube and secured at their other end to the bottom of levers (37) and (41). The tube revolved in ball bearings and carries with it a steel rod (45), the upper end of which is securely fastened to the upper end of the tube, and the lower end fastened to the frame of the machine. When the belt drum and tube are rotated, the rod inside of the tube is in torsion. This torsion resistance forms part of the total resistance of the machine and is a constant for the same travel of the recording pen.

To the upper end of the tube (44) are secured two radial arms (46 and 47 upper right detail) whose ends are finished to a circle having its centre at the centre of the tube. By means of thin, steel tapes the rotary motion of the circular end of the arm (47), is translated into rectilinear motion of the carriage, which carries the recording pen. Arm (46) is connected by means of steel tapes, with a rotary dash pot (48), shown in the upper right detail of figure 6. The fixed vanes (49) project from the walls of the dash pot cylinder. The shaft (50), is provided with vanes (51), which rotate in the cylinder when the shaft rotates. The cylinder is filled with oil and passages (52) permit the oil to pass from one side to the other of the moving vanes. These passages are adjustable by means of spindles (53), so that the resistance imposed by the dash pot may be varied to suit the requirements.

Figure 8 shows the recording table, over which an endless strip of paper 18 inches wide is mechanically drawn, and upon which a continuous record of the test is made. The paper is driven by direct connection with one of the supporting wheels upon which the locomotive drivers rest. The speed reduction is so arranged that when the locomotive under test travels one mile on the supporting wheels, the paper moves 52·8 inches, giving a scale of 100 feet to the inch upon the diagram. In order to secure the accurate movement of the paper, it passes between a finely corrugated brass roller and another roller covered with rubber. The winding drum to which the paper is finally delivered is arranged to slip upon its shaft, in order to accommodate its constantly increasing diameter as the test progresses.

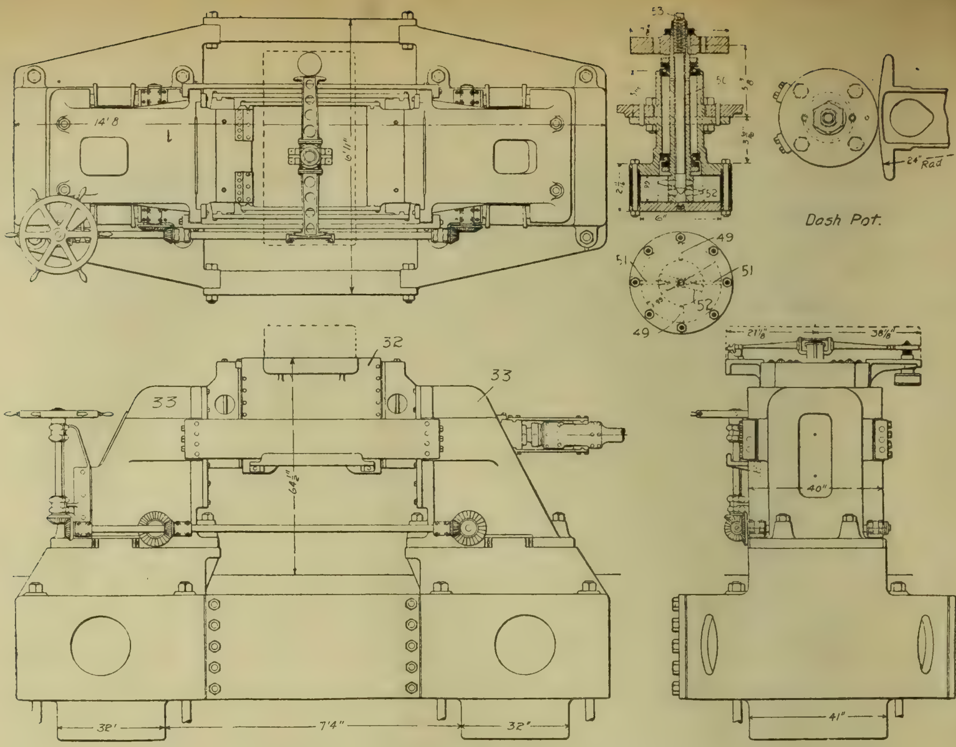


Fig. 6. — 80,000 lb. traction dynamometer.

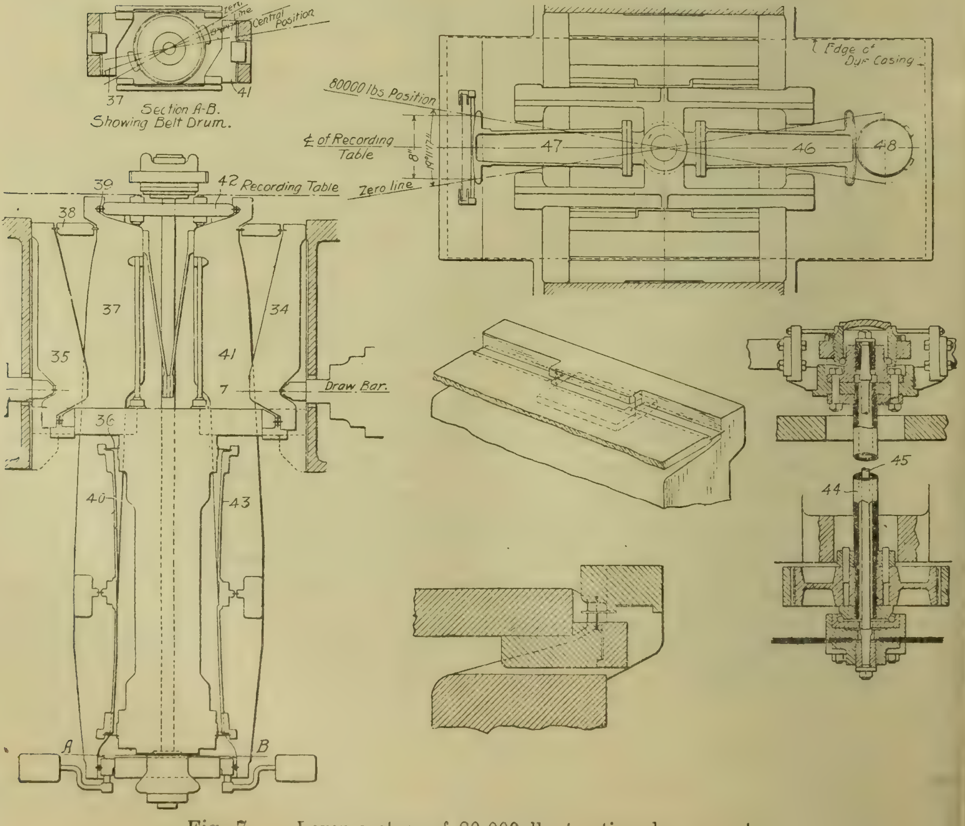


Fig. 7. — Lever system of 80,000 lb. traction dynamometer.

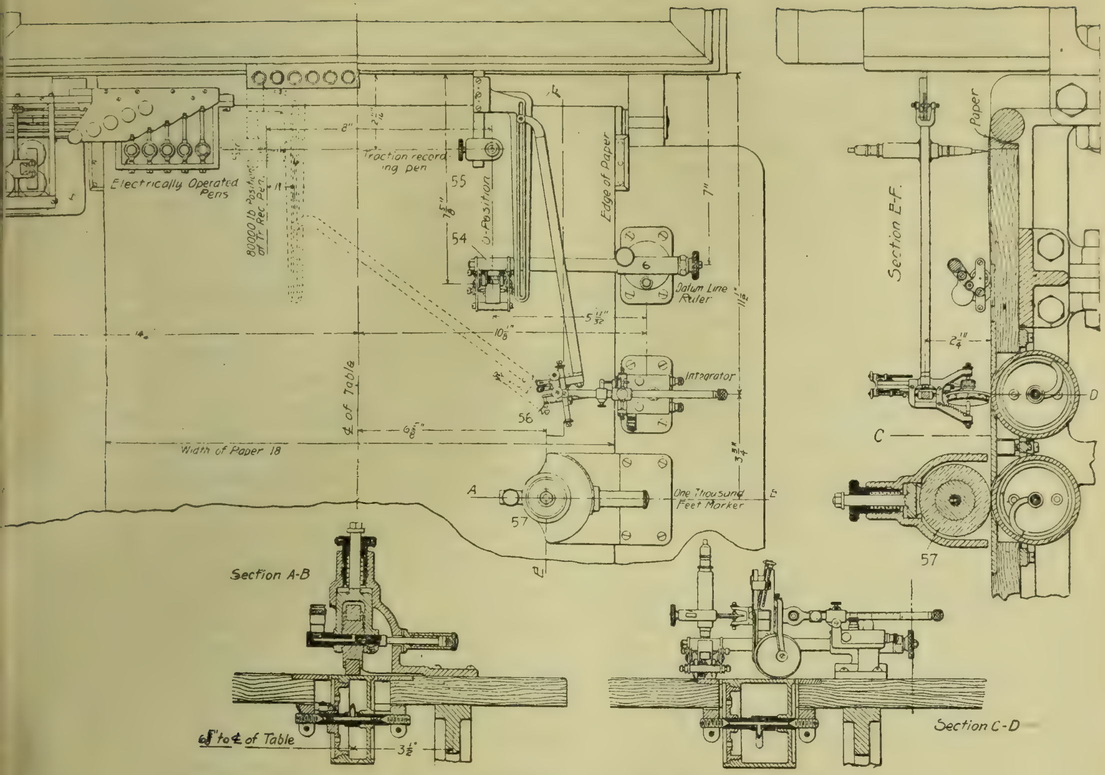


Fig. 8. — Recording table of Pennsylvania Railroad traction dynamometer.

Referring to figure 8, a datum pen (54) marks a continuous straight line upon the paper. The traction recording pen (55) moves across the paper perpendicular to the datum line, its distance from the datum line being dependent upon the force transmitted by the drawbar from the locomotive. The maximum travel of this pen away from the datum line is eight inches. Two sets of springs (40 and 43, fig. 7) are provided. With the heaviest set the eight inch movement of the traction pen corresponds to a load of 80,000 pounds upon the drawbar, which represents the maximum capacity of the dynamometer. With the other set of springs, the eight inch motion of the traction pen corresponds to a pull of 40,000 pounds upon the drawbar, and with all the flat springs removed, the eight inch motion corresponds to a 16,000 pound load upon the drawbar. The total motion of the drawbar to give the eight inch movement to the recording mechanism, is but 0·04 of an inch. The multiplication of the recording and weighing mechanism is therefore 200 to 1.

An integrator (56, fig. 8) is provided and attached to the traction recording mechanism, so that the foot pounds of work performed by the locomotive is automatically summed up. Five additional electrically operated pens are provided. They normally draw continuous straight lines. One of them is electrically connected with a clock, so that each second is indicated by a jog in the straight line which this pen normally draws. Another pen is electrically connected to a roller (57) which is rotated by the recording paper, causing the pen to make a jog in the line for every thousand feet which the locomotive travels. Another pen is electrically connected to the integrator (56) and makes a jog in its line every time the integrator measures one square inch. The remaining electrically operated pens are used for recording such features of the test as taking indicator cards, etc.

The dynamometer has been placed further away from the locomotive than it was in St. Louis, to allow more room for the firing platform. A steel and concrete house has recently been added, which completely incloses the dynamometer and those attending its operation, thereby protecting the working parts from dirt occasioned by the handling of coal and ashes in the immediate vicinity.

For handling the coal used by the locomotive, a very complete plant has been installed. Bottom dumping coal cars are run in on the track beside the building. They are dumped into a large hopper directly beneath the ash bin shown in figure 4. From this hopper the coal is carried by a bucket conveyor to two elevated reinforced concrete pockets, each of which has a capacity of about 50 tons. These pockets are located over the larger of the two rooms directly back of the testing laboratory. Each coal pocket is provided with a bottom cut-off gate at a convenient height above the main floor, as shown in the photograph. Coal from the bins, as needed, is discharged through the gates into wagons holding about 1,000 pounds each, which are run over weighing scales, pushed out to the locomotive, raised by a hydraulic elevator to the firing platform, and dumped. Ashes from the locomotive are discharged at the pit level, placed in a wagon, raised on the hydraulic elevator to the level of the main floor, and run into a chute leading to a conveyor, delivering into the ash bin over the outside track. From there the ashes are discharged into car run in on the track below.

Water used in the locomotive boiler is taken from a water supply tank located in the corner of the laboratory. The water first passes through a meter, the reading of which is used as a check upon the weighing tanks. A small motor driven centrifugal pump returns to this supply tank the overflow from the injectors used on the locomotive.

The stack into which the locomotive discharges is a great improvement over the one originally used in St. Louis. It embodies the principle used many years ago, for wood burning locomotives, but, of course, on a very much enlarged scale, so that the exit of gases shall be free enough not to cause smoke to go back into the building between the top of the locomotive stack and the bottom of the plant's stack. Within the enlarged head is a deflector for carrying the sparks to the outer portions of the casing, where they fall out of the flow of gases and drop into a hopper, from which they are eventually removed and weighed. The entire stack is supported upon a truck which is adjustable over a distance of 16 feet and 6 inches lengthwise of the building, in order to bring the stack directly over the locomotive's stack wherever the latter may happen to be located when the locomotive is ready for test. The opening in the roof is provided with a hood by which it is always closed to the weather, regardless of the position of the stack.

[625 .2 (06 & 625 .216]

TESTS OF MASTER CAR BUILDERS' COUPLERS.

Figs. 1 to 3, pp. 901 to 909.

(*Railroad Gazette.*)

During the past year, the committee has made a thorough investigation if the breakages and failures of steel couplers with the view of obtaining some reliable data concerning the location and nature of such fractures, and to recommend such changes as will strengthen the couplers in the weakest parts, improve them, and to reduce the failures to a minimum.

An examination was made of approximately 5,000 broken steel couplers and 3,000 broken steel knuckles, together with the locks or their substitutes, of the more prominent types of couplers.

The locations of the breakages of the couplers and knuckles are shown in the accompanying diagram, and comprise the most common fractures found. For convenience, the detail breakages, which localize around a particular part of the coupler or knuckle, have been combined.

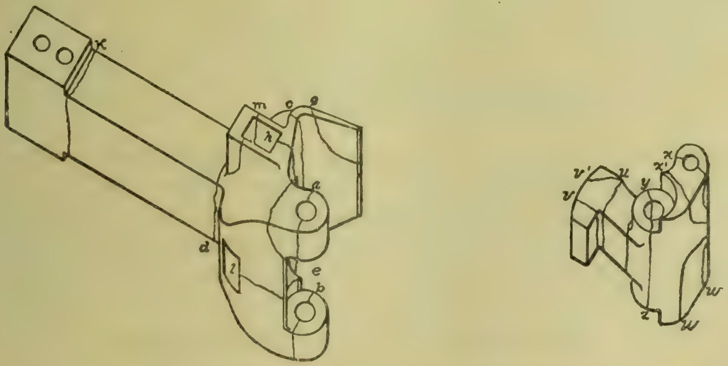


Fig. 1. — Location of coupler and knuckle breakages.

The various breakages have been grouped as follows :

COUPLER.

(Combined breakages.)

A = Combined breakage of the lugs, comprising :

- *a* = Upper pivot pin lug.
- *b* = Lower pivot pin lug.
- *e* = Just back of upper lug.

H = Combined face breakage, comprising :
c = Neck of the guard arm.
g = Upper corner of guard arm.
h = Through face into locking-pin hole.

D = Combined failure of the shank, comprising :
d = Immediately behind horn.
k = Immediately in front of butt.
Bent shank.

(Singular breakages.)

l = Side-wall of head behind knuckle tail.
m = Across horn through locking-pin hole.

KNUCKLE.

(Combined breakages.)

U = Combined breakage of knuckle-tail bearing, comprising :
u = Knuckle tail immediately forward of lock bearing.
v = Knuckle tail through lock bearing.

X = Combined breakage of coupling lugs, comprising :
w = Lower lug through link-pin hole or corresponding position on solid knuckle.
w = Neck of lower lug or corresponding position on solid knuckle.
x = Upper lug through link pin hole or corresponding position on solid knuckle.
x = Neck of upper lug or corresponding position on solid knuckle.

Y = Combined breakage at pivot pin hole, comprising :
y = Directly through pivot pin hole.
z = Immediately back of pivot pin hole shoulder.

(Singular breakages.)

v = Knuckle tail behind lock bearing.

The couplers represented were not all M. C. B. standard, that is to say, only about six of the types shown on the diagrams had been tested under the M. C. B. specifications to a greater or less extent during the last two years. The latest type of couplers which have been on the market for a year or two are not shown, inasmuch as an insufficient number of these later designs were found broken to compare them with accuracy.

Breakage of 5 by 5-inch shank couplers.

Lug breakage. — In the 5 by 5-inch shank couplers, the lug breakages have decreased in the later type of couplers, which can be attributed to the strengthening of the lugs in design by the manufacturers, and the increased amount of metal which was added when the contour lines were last changed. The upper lug breakage has been the most serious of the three breakages grouped under this head, which can be accounted for by the fact that most lug breakages are caused by broken knuckle pins, the lower half dropping out and the upper half remaining in the head. In three types of couplers, the breakage *e* just at the back of upper the lug, was greater than through the upper pivot pin lug, which can readily be overcome in the design.

Face breakage. — The combined face breakage is generally on the increase, and is by far the greatest point of failure in the coupler, and it is evident that the strength of the face has not kept pace with the increasing forces which affect it. This in part results from the greater amount of attention the lugs and the shank have received in the design, and is further accounted for by the lack of room to strengthen the section, which is limited to some extent by the space occupied by the locking mechanism, particularly with the bar type of locks. The breakage through face into locking-pin hole is by far the most prominent, which is to be expected, as this is the most limited section. The guard arm breakage has run very evenly except in isolated cases, the box and rib design showing no general difference in their failures. The fracture through the upper corner of the guard arm, is negligible without exception.

Shank failures. — The combined shank failures appear least on the early modern couplers, while on the later types they are on the increase. This increase is chiefly due to bent shanks, but the breakage back of the head has also shown an increase, while the breakage immediately in front of the butt is also in the ascendancy. In almost every case of couplers having bent shanks, the bend is in the vertical direction. It is believed that the shank failures can be materially reduced by more attention given to the individual design of coupler by the manufacturer.

Breakage of side-wall and across horn. — Of the two odd breakages, the one through the wall behind the knuckle has been quite large in three types, but is on the decrease in the latest type of couplers. There should be no breakage at this point, as there should be little strain, and the design can be changed to provide for any strength necessary, without affecting any other vital part of the coupler. The breakage at the horn has been low, with one exception. As an emergency stop, the horn should be designed strong enough to withstand the shocks, but with the introduction of properly designed draft gears of sufficient capacity, the trouble from horn breakage should disappear.

Breakage of 5 by 7-inch shank couplers.

Lug breakage. — On 5 by 7-inch. shank couplers, which are all modern, lug breakages show an even greater decrease on the later types than on the 5 by 5-inch shank couplers, and with the three exceptions are below 10 per cent of the total breakages. Most of these couplers are equipped with the knuckle tail hook to prevent the knuckle from pulling out when the pivot pin breaks, which assists in preventing the lugs from breaking.

Face breakage. — The face breakages are by fa rthe most prominent, and on all the types are considerably above 50 per cent of the total breakages. The breakage into face through the locking-pin hole and the breakage at the neck of the guard arm, constitute the largest percentage of the failures, and these two breaks vary in the different types of coupler; in some makes, the breakage through face into lock-pin hole is the most numerous, whereas, in the other types, the neck of the guard arm is broken more frequently. The failure of the upper corner of the guard arm has become negligible.

Shank failures. — The shank failures in three instances are above 10 per cent of the total failures, and this is mainly due to bent shanks. The breaks immediately behind the horn and directly in front of the butt, are rather constant for the different types of couplers and about uniform in the two breaks, both of which are very low, only one case reaching 7 per cent of the total failures.

Breakage of side wall and across. horn. — The breakage through the side wall of head behind knuckle tail, shows excessively high in two cases, one type showing 28 per cent and the other type 21 per cent of the total failures. The break across horn through locking-pin hole has almost disappeared, probably due to the more efficient draft gears applied with these couplers on the later cars, which prevent the horn from coming in contect with the end sill.

Comparison of the breakages of the 5 by 5-inch and 5 by 7-inch shank couplers.

Shank failures. — The percentages of the combined shank breakages of the 5 by 7-inch shank couplers average less than 3 per cent lower than the shank failures of the 5 by 5-inch shank couplers. Bending has been the most serious failure of the shank in the late types, and as the shank generally bends vertically, we do not obtain the full benefit from the additional 2-inch width of shank, as the additional metal is not in the right direction to stop the vertical bending most effectively.

Face breakages. — The percentages showing the combined breakages of the face are slightly lower for the 5 by 5-inch shank couplers, but the breakage through face into locking-pin hole is lower on the 5 by 7-inch shank couplers. This is accounted for by the increased width of shank backing up the guard arm, the benefit accruing directly to the section forward of the locking-pin hole, as the guard arm failures in the 5 by 7-inch shank couplers are very much higher than the 5 by 5-inch shank guard arm failures. The results show, without question, that the weakest point of the couplers is in the section of the face immediately forward of the locking-pin hole. The neck of the guard arms should also receive further consideration in the way of strengthening.

Breakage of knuckles.

The breakage of the solid knuckle is not confined to any particular point, but may be said to vary with the construction of the knuckle, the main failures being combined breakage at pivot pin-hole, knuckle tail behind lock bearing, combined breakage of knuckle tail bearing and combined breakage of the coupling lug.

Breakage at pivot pin-hole. — The combined breakage at pivot pin-hole is divided into the breakage through pivot pin-hole, and the breakage through the tail immediately behind pivot pin-hole shoulder. The breakage behind the shoulder is more serious in some knuckles than the actual breakage through the pivot pin-hole.

Knuckle tail behind lock bearing. — The breakage of the knuckle tail behind lock bearing, or in other words, of the hook which prevents knuckle from pulling out when pivot pin breaks, has been pronounced, all but two of the solid knuckles represented being equipped with this safety device. The breakages show the value of the knuckle tail hook as well as the weaknesses. It will be difficult to strengthen this hook in most knuckle-throwing couplers, but it should be done wherever possible.

Breakage of coupler lug. — Lug breakage has diminished from the most prominent failure in slotted knuckles to one of minor importance in the solid type. The fracture through the end of coupling lug on the upper portion of the knuckle, and the break through neck of coupling lug on the upper portion of knuckle, are the most prominent. A number of these fractures were the direct result of improperly designed cores, and of cores slipping when casting knuckles which have lightening cores through lug.

Defective metal, poor coring, etc.

The percentage of each type of 5 by 5-inch and 5 by 7-inch shank couplers, also the solid and slotted knuckles of those examined, in which the fractures could be attributed to defective metal and poor coring, should be carefully weighed in drawing conclusions, as the number of couplers examined which were broken, and the percentages of the same showing defective metal may be a very small proportion of the total number of couplers or knuckles in service; whereas, on another type, this ratio may be much larger, and, therefore, no deductions can be made between the different types of couplers. For example : The total number of solid knuckles found broken in proportion to the number in service was very small, and not to be compared with the number of slotted knuckles broken to the number in service. If, however, the defective metal or improper coring would be eliminated, the relative failures in the same type of coupler or knuckle would probably be reduced by the percentages shown.

The percentage of defective castings among the 5 by 5-inch shank couplers, are decreased with the development, and the types which have been tested most generally under the M. C. B. specification. This also holds true in the 5 by 7-inch shank couplers, where, with one exception, the tested couplers when broken, have shown less defective metal than those not tested.

In examining the broken knuckles and defective locks, the committee has found that many knuckles and locks have been purchased for repairs which were manufactured by steel foundries other than the makers of the original couplers. A large proportion of such knuckles and locks have varied from the original design to such an extent that it directly affected the operation of the coupler, which not only results in troubles from parting, but also has a direct influence on the breakage of the coupler and knuckle parts. This is aside from the question of inferior metal used in such knuckles, and the fact that they are not tested under M. C. B. specifications. Separate knuckles for repairs should be purchased according to M. C. B. specifications for economy, as well as in justice to the owners of the cars who have originally applied couplers in compliance with the Interchange rules and standards of the Master Car Builders' Association.

A large number of locks, knuckle throwers and other like parts were examined. The data obtained are of no particular value for comparison, but the examination emphasized a number of points to which the committee desires to call attention.

A great majority of the lock failures were due to the breakage of the lock chain attaching the lock block to the uncoupling lever chain, which is the weak point of a lock of this type. It is not within the province of the committee to make definite recommendations concerning the form of lock, as most of the coupler patents are based on this feature, but where the flexible link connection is used from the lock block to the uncoupling lever chain, it should be strengthened.

Conclusions.

This investigation has pointed out wherein the different types of couplers and knuckles are failing, and has satisfied the committee that a closer observance of the M. C. B. specifications in purchasing couplers and the insistence of the railroads to have the couplers tested in accordance with the requirements of the Association, will overcome much of the trouble from breakage of couplers, knuckles and parts which is now being experienced. The use of the M. C. B. specifications is being extended, and in this connection, attention should be called to rule No. 59 of the Interchange code, which provides that : " When using materials for repairs to foreign cars for which the Master Car Builders' Association has adopted specifications as a standard, the materials must comply with the requirements of these specifications." Therefore, it is a violation of the rules of interchange for any railroad company to apply any coupler or knuckle to a foreign car in repairs, that is not in accordance with the specifications and which has not been tested.

Defective uncoupling arrangements are an increasing source of trouble, on account of the bending of the uncoupling rods, breakage of uncoupling chains, and loss of pins from the clevises. The breakage of these chains is very often due to the excessive slack in the draft rigging, and as the length of chain must necessarily be limited to obtain the proper amount of lift for the locking-pin, it cannot well be lengthened. With the knuckle-throwing couplers, the amount of lift of the locking-pin is increased, which aggravates this trouble. Some better means should be provided for operating the locking device, but the committee is prevented from making any definite recommendations on account of patented device. In order to provide for increased strength at this point, a recommendation is appended to make the diameter of the eyelet at the top of the locking device for uncoupling rigging 1 $^1/_{16}$ inch.

The lock-set within the head of the coupler is now standard, so that there is no longer any necessity for the lip on the outside bracket, shown in recommended practice, sheet " B." The uncoupling lever is frequently allowed to hang on the lip of this casting while coupling cars, and when this is done, it results in damage to locking-pins and sometimes causes breakage of knuckles and couplers.

Under recommended practice for uncoupling arrangements, all the fifth paragraph should be omitted, except the first sentence reading as follows, " Diagram No. 3 shows the application to a car having projecting end sills," to comply with this recommendation.

In order to conform to the recommendation to make standard the location of the lock lift in the central longitudinal plane of the coupler, it is recommended that diagram No. 2 be omitted from sheet M. C. B. " B," and under recommended practice for uncoupling arrangements, fourth paragraph beginning " Diagram No. 2. shows," be omitted, inasmuch as diagram No. 2 shows the lock located 3 inches from the vertical center line of the coupler. For a similar reason, paragraph seven under Uncoupling attachments

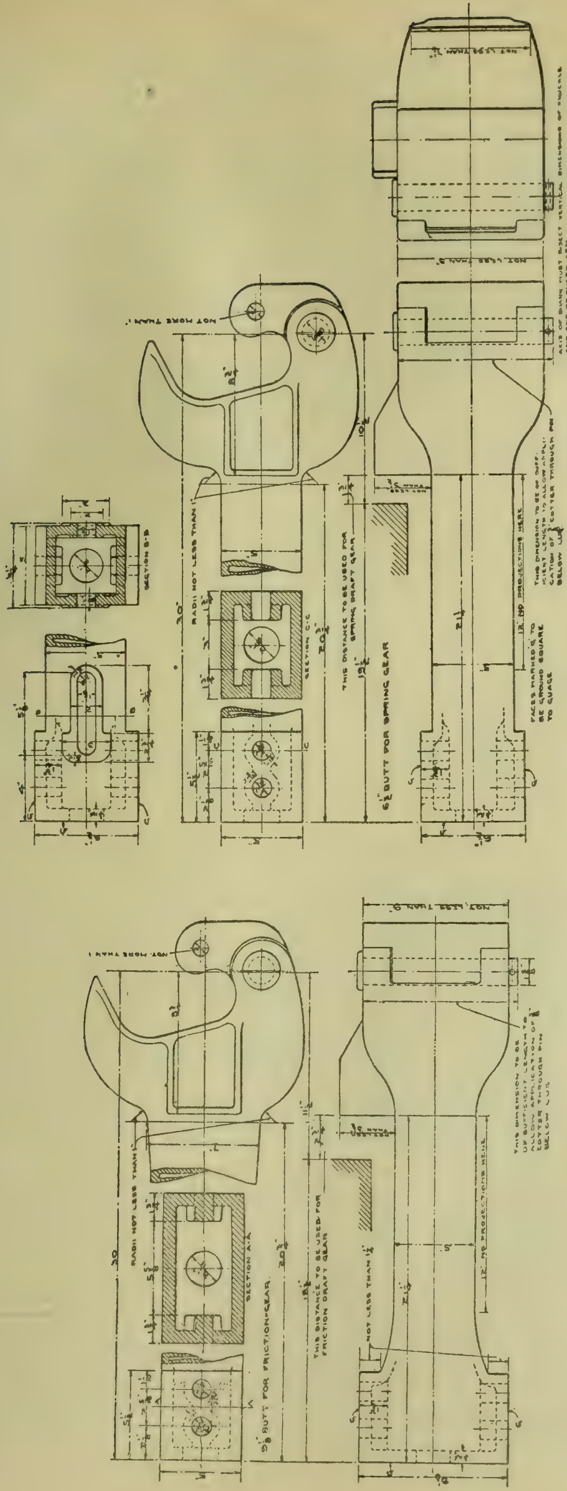


Fig. 2. — Recommended revised drawing of left-hand half of sheet M. C. B. 11.

beginning with "There are some designs of Master Car Builders' couplers, etc.," should also be omitted.

The location of the lock lift in the central longitudinal vertical plane of the coupler, located between the striking horn and the contour lines, and operated from the top by an upward movement, was adopted as recommended practice in 1905. It is recommended that this requirement be advanced to standard and included in the specifications, inasmuch all the couplers made under M. C. B. specifications, conform to this recommendation, and the best working couplers are of this design, besides which, it forms a common basis for uncoupling arrangements which is of great advantage.

Since all couplers manufactured under M. C. B. specifications are provided with a knuckle designed not to pull out when the knuckle pin breaks, and the examination of breakages shows that this design has greatly prevented lug breakages when the knuckle-pin breaks, the committee recommends that this be advanced to standard and included in the specifications.

As the various knuckle-throwing devices employed in modern couplers have not had sufficient service to determine their working qualities or ultimate efficiency, your committee believes that this feature should remain as recommended practice for at least another year.

The specifications for separate knuckles while appearing under Standards, have never been adopted as such, but were made recommended practice in 1904. They have now been given sufficient trial and with the minor changes suggested in this report, the specifications for separate knuckles should be adopted as standard. The last paragraph appearing under this head and beginning, "Your committee has tested," should be omitted, as it is not a part of the specifications.

Attachment of couplers to cars.

The committee received a recommendation to increase the number of rivets in coupler butt from two to three. The proper function of the rivets should be to hold the yoke arms tight against the butt, so that the yoke gibs have a full bearing on the butt. With a three-rivet connection as an additional standard, there would be two non-interchangeable types in service, the individual maintenance of which would scarcely be justified by the increase in strength, and the need of which is doubtful. In a connection subject to lateral bending strains, such as that between the yoke and coupler, the vertical rivet method of fastening may not be the best, so until some better method can be devised, and its worth proved, it would seem advisable to maintain the parts interchangeable to facilitate repairs. In order to increase the bearing of the present yoke upon the butt, the committee recommends increasing the length of the gibs in front of the butt $^1/_2$ inch on the 9 $^1/_8$-inch butt couplers, which will necessitate decreasing the dimension of the opening between the gibs from 7 $^3/_4$ to 6 $^3/_4$ inches, the remaining dimensions of the yoke to be the same as the present recommended practice.

More care should be exercised by the manufacturers in casting and grinding the top, bottom and back face of the butt to insure their being square, which will increase the bearing surfaces for the yoke; also the bearing surfaces in front of butt for the gibs of the yoke. A dimension showing 1 $^3/_4$ inch depth of bearing, top and bottom, for rivets

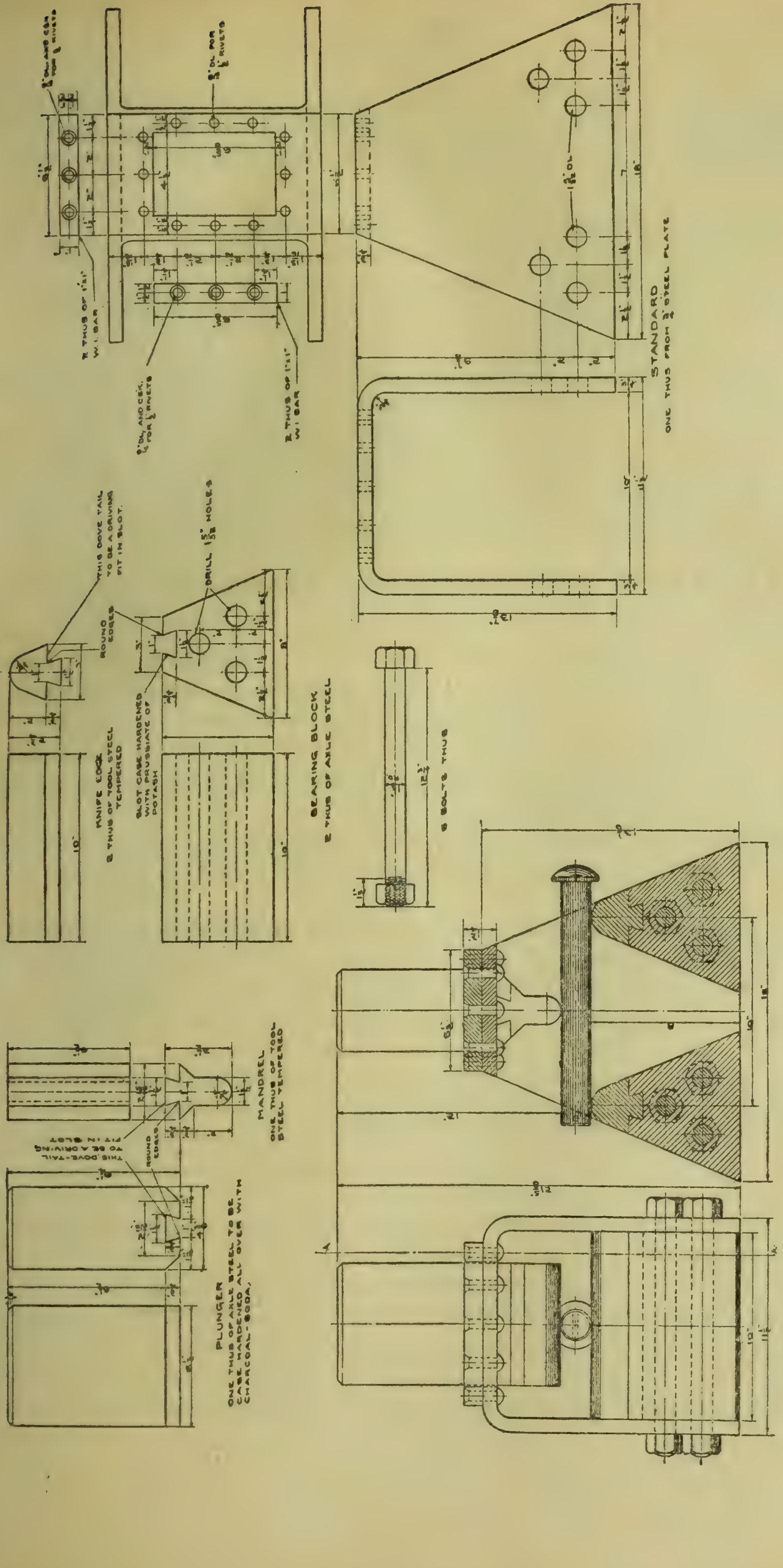

STANDARD
ONE THUS FROM 3/4" STEEL PLATE
2 THUS OF 1"×2" W.I. BAR
2 THUS OF 1"×1" W.I. BAR
KNIFE EDGE
2 THUS OF TOOL STEEL TEMPERED
THIS DOVE TAIL TO BE A DRIVING FIT IN SLOT.
ROUND EDGES
DRILL 1 5/32" HOLES
SLOT CASE HARDENED WITH PRUSSIATE OF POTASH
BEARING BLOCK
2 THUS OF AXLE STEEL
6 BOLTS THUS
MANDREL
ONE THUS OF TOOL STEEL TEMPERED
THIS DOVE-TAIL TO BE A DRIVING FIT IN SLOT
PLUNGER
ONE THUS OF AXLE STEEL TO BE CASE HARDENED ALL OVER WITH CHARCOAL-SODA.
SECTION A-A.
ELEVATION

Fig. 3. — Construction of apparatus for drop test of knuckle pivot pins.

in the butt will also aid in this matter. The committee further recommends that the following recommended pratices be advanced to standards, in view of the great advantage to be thus attained in future repairs on the large number of steel cars now being constructed.

" That the spacing between steel center sills be 12 $^7/_8$ inches.

" That front and back stops with rivet holes $^{15}/_{16}$ inch. in diameter be spaced as shown on sheet M. C. B. ' B,' drawings 'A' and ' B.'

" That the spacing between coupler horn and buffer beam be 1 $^3/_4$ inch for all spring gear and 2 $^3/_4$ inches for all friction gear.

" That followers be made of wrought iron or open hearth steel 1 $^5/_8$ inch thick for tandem spring gear, and 2 $^1/_4$ inches thick for twin spring and friction gear.

" That the total side clearance of the coupler be not less than 2 $^1/_2$ inches. The words ' not less than ' have been added to this recommended practice in advancing it to a standard, as the original intention was to specify the minimum clearance, and the committee is of the opinion that the increase of the clearance, should not be limited at this time.

" That the butt 5 by 5 $^1/_2$ by 9 $^1/_8$ inches for use with friction draft gear be advanced to standard."

Inasmuch as the original design of the shank has been changed in foundry practice tc the square type, and since it is desirable to more definitely specify the construction of the butt and other details, the committee suggests that the left-hand of sheet M. C. B. 11 be modified to conform to the drawing shown. This sheet shows many unimportant changes to conform to present standards, etc. The important changes other than those which have already been explained, are:

The back wall of butt changed to $^3/_4$-inch thick, inasmuch as the tail pin has fallen into disuse, and there is no need of having such a heavy block of metal on the end of the butt.

The width of the butt is changed from 4 to 5 inches on both sizes of shanks, as this dimension will provide for properly securing the yokes now represented in recommended practice, and modern couplers are being furnished with butts so constructed.

A dimension of not less than 1 $^1/_4$ inch is shown forward of the 9 $^1/_8$-inch butt to provide for this $^1/_2$-inch increased length of gib in the 9 $^1/_8$-inch yokes.

A limiting dimension of not more than 1 inch is shown for the diameter of core hole in lug of knuckle, to prevent a recurrence of the slotted knuckle weakness.

A note is added to the effect that there shall be no projections on the bottom of the shank from the line of the horn back for 12 inches in order that the working of the shank on the carrier iron shall not be interfered with.

It has been suggested that the marking on couplers to indicate that they comply with the M. C. B. specifications be stamped instead of cast, so that the letters " M. C. B." will be applied after the couplers have passed the test. This will prevent any couplers from receiving the marking " M. C. B." until they have complied with the specifications, and the committee recommends that paragraph 8 of " Specifications for M. C. B. automatic couplers " be changed so as to read : " 8. Every coupler and knuckle made to comply with these specifications, must have a slightly raised plate or flat surface cast upon the head in plain view where it will not be subject to wear. After a lot of complete couplers have successfully passed the inspection and tests prescribed below, the letters 'M. C. B.' must be legibly stamped upon the plate on each coupler and knuckle; this mark to be evidence that the complete coupler is an M. C. B. standard." This marking is as important for identification on the knuckle as on the coupler, therefore the knuckle has been included in the above. The committee also recommends that a paragraph be added to the "Specifications for separate knuckles" as follows : "7. Every knuckle made to comply with these specifications, must have a slightly raised plate or flat surface cast upon the head in plain view where it will not be subject to wear. After a lot of knuckles have successfully passed the inspection and tests prescribed below, the letters 'M. C. B.' must be legibly stamped upon the plate on each knuckle; this mark to be evidence that the knuckle is an M. C. B. standard."

In the "Specifications for knuckle pivot pins" given below, a limit gauge is necessary to determine that the pins are of the proper diameter. Limit gauges for round iron are prescribed under M. C. B. Recommended practice, for sizes of round iron up to 1 $^1/_4$ inch, and the committee suggests that the standing committee on supervision of standards and recommended practice, add dimensions of such a gauge for round iron of 1 $^5/_8$ inch nominal diameter; the total variation allowed to be increased proportionally as compared with that of the smaller sizes. The use of this standard gauge has been prescribed in the specifications.

Knuckle pin specifications.

Specifications for knuckle pins purchased for repairs are very necessary, and the specifications appended are recommended for adoption as Recommended practice.

After experimenting with the various methods of testing under static loads, it was finally decided to abandon the static test and use the standard M. C. B. drop test machine as the most convenient, efficient and best method of testing. The only additional apparatus necessary consisted of two triangular shaped blocks topped by round bearing edges with a radius of $^3/_4$ inch and held by means of a suitably formed plate, 10 inches center to center, above the bearing edges. The plate war formed into a suitable shape for retaining a vertical plunger which was also provided with a round bearing edge of the same radius. It was designed to place the pin across the two lower supports and rest the upper plunger on it in the center; the whole device being placed on the anvil block of the drop testing machine. Construction of the apparatus is shown herewith.

Some 70 or 80 knuckle pins were secured and tested. The pins tested varied in size from 1 $^3/_8$ to 1 $^5/_8$ inch, and the results obtained with each group were remarkably uniform. Each pin was subjected to a blow of the 1,640-lb. weight falling 3 feet, irrespective of the size of the pin tested. The amount of bending was measured by finding the angle included after the pin has been tested, and subtracting it from 180°. The amount of set was measured by noting the height of point on the vertical block before and after the test, the difference between the two dimensions showing the amount of set of the pin between supports, also including any indentation. In comparing the tensile strengths, elongations, chemical analyses, and the results of the drop test of the pins of the various groups, it was found that the method of manufacture affects the result of their test under the drop to a large extent, so that two pins of somewhat different analyses may show like results depending on their heat treatment and *vice versa.*

Comparing the data obtained from these tests with the results obtained from similar pins under actual service conditions, it seems advisable to specify a test which will insure obtaining a pin which is not too brittle, but on the other hand is stiff enough to stand up under service conditions. This test should require a pin to bend cold at least 15°, but not more than 35°, and not to show any fractures under a blow of 1,640 lb. at 3 feet.

The object of using angles as limits instead of the amount of set in inches, is to eliminate the effect of the indentation by the supports and plunger. Suitable angular limit gauges can be easily constructed and used for measuring the angle of deflection. These gauges should be long enough to measure the angle at least 3 inches from the center of the bend on each side so as to eliminate the possibility of a false measurement of the angle.

The additional apparatus can be constructed at a small cost from the accompanying drawings, and the pins can be tested at the rate of from 15 to 20 per hour, or testing three out of every 500, from 2,500 to 3,500 pins passed per hour, exclusive of the surface inspection.

Specifications for knuckle pivot pins.

All knuckle pivot pins ordered under these specifications must be made from open-hearth steel properly forged and then annealed and must not be painted :

1° Knuckle pivot pins will be subject to the inspection and test of the above-named company as to their general condition and strength. The tests and inspection will be preferably made at the place of manufacture, where assistance and labor necessary to make satisfactory and prompt inspection and shipment must be furnished free by the manufacturer. The testing machine, approved by the Master Car Builders' Association, must be used in the test of knuckle pivot pins;

2° Knuckle pivot pins will be ordered as far as practicable in lots of 500; for each lot ordered the manufacturer shall furnish three extra pins, and in the event of additional pins being required to carry out the prescribed tests, they shall be furnished free of cost by the manufacturer;

3° All pins must be of such size as will enter the plus end and will not enter the minus end of a limit gauge for 1 $^5/_8$-inch round iron as prescribed in M. C. B. recommended practices under "Limit gages for round iron," and must not vary more than $^1/_8$ inch above or below the proper length. The lower end of the pin must be cut off square and have at least $^1/_4$ inch bevel or chamfer. The cotter-pin hole to be properly drilled for $^3/_8$-inch cotter. The head must be well formed, and pins which are not straight and true and those which have blisters or surface defects of any kind will be rejected.

Inspection. — Knuckle pivot pins, after having been thoroughly inspected by the manufacturer to see that they meet the requirements as to interchangeability, soundness, dimensions of parts, etc., herein specified, should be arranged in lots of 503. The inspector shall then inspect and gage each pin as to its compliance with drawing sizes and for surface defects.

After this inspection, the inspector shall select three pins taken at random from each lot or lots, as provided for above. and subject them to the cross-bending drop test as hereafter specified. If one of the pins fails to stand the test as prescribed below, and the other two pass, three more pins shall be selected at random from the same lot from which the first pins were taken; if all three of these pins stand the prescribed test, that lot of pins shall be accepted, otherwise that lot of pins shall be rejected, and another lot substituted and tested in the same way. If two or more pins fail to stand the test, originally, the lot represented will be rejected without further consideration.

Physical test. — The cross-bending test will be made in a standard M. C. B. drop-testing machine, the pins resting on rounded supports, held rigidly 10 inches center to center, to be subjected to a blow by the weight falling a height of 3 feet. The blow of the weight should be transmitted to the specimen by a block having a round lower edge resting on the specimen. The radius of all these round edges is to be $^3/_4$ inch. All pins are to be tested cold and must not show any cracks or fractures. The bend must be directly under the nose of the plunger. Pins will be rejected if they break, or crack, or show a deflection less than 15° or greater than 35°.

The report is signed by R. N. Durborow (chairman), G. W. Wildin, F. W. Brazier, F. H. Stark.

[656 .256.3]

A NEW SYSTEM OF BLOCK SIGNALLING ON THE PENNSYLVANIA RAILROAD.

Figs. 1 to 3, pp. 915 and 916.

(*Engineering News.*)

A new system of signaling, which involves some novel features and some distinct departures from ordinary practice, is now in experimental service on the Pennsylvania Railroad. It was developed by a special committee of the railway company's officers, and is stated to have proved very satisfactory. The special features may be enumerated as follows : 1° The semaphore arms move upward instead of downward from the horizontal position (" stop ") to the inclined (" caution ") and vertical (" clear ") positions. 2° Two semaphore arms and two lights are used for every indication, except those governing low-speed movements ; for these latter, an additional small arm and dim light are provided. 3° The signals are used to give two kinds of indications when at the " stop " position : (A) Stop, wait a specified time, and then proceed. (B) Stop and remain until the signal indicates " proceed ". The former is distinguished by a longer upper arm and the two lights offset from a vertical line (as in fig. 1). The latter is distinguished by having the arms of equal length and the lights disposed in a vertical line (as in fig. 2). 4° At interlocking plants, the signals indicate for speed rather than for routes.

This new system has been in use for about four months between Philadelphia (49th Street) and Elwyn, Pa., on the Central Division of the Philadelphia, Baltimore & Washington Railway. The distance is about 12 miles, all double track, with the exception of about 4,000 feet at Elwyn, this being the end of the double track portion of the line. There are about 17 blocks, 3,500 to 4,500 feet long, with 156 signals. The blocks include crossovers, sidings, the junction of a branch, and the connection of the single and double track sections ; a great variety of conditions has, therefore, to be covered by the signal equipment. During the morning rush hours, there are ten trains in a little over two hours, and during the evening, there are nine trains in a little less than two hours, the average time between trains in both cases being thirteen minutes. During December, there were three failures of signals : one due to a broken wire and another to a weak battery, while the cause of the third was not discovered.

At each signal, the two arms for each track are 6 feet apart vertically. In most cases, they are carried on steel posts set at the side of the track, the base of the post forming

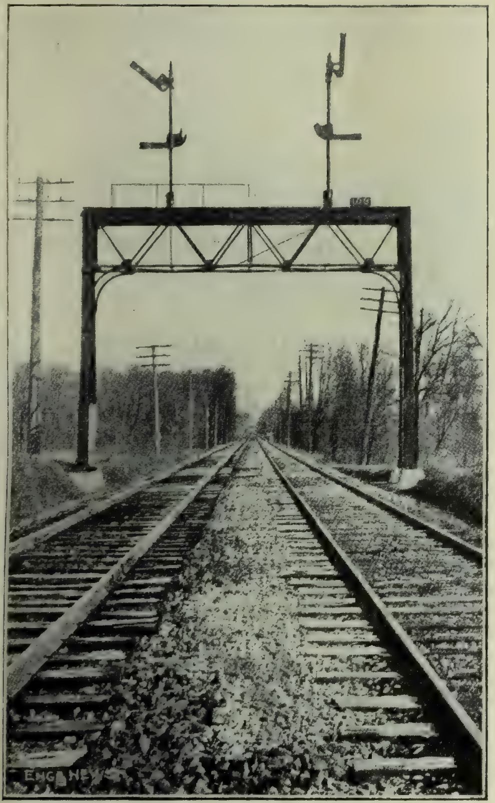


Fig. 1. — New block signals on the Pennsylvania Railroad (central division of the Philadelphia, Baltimore & Washington Railroad); signals on bridge at Swarthmore, Pa. (view looking north).

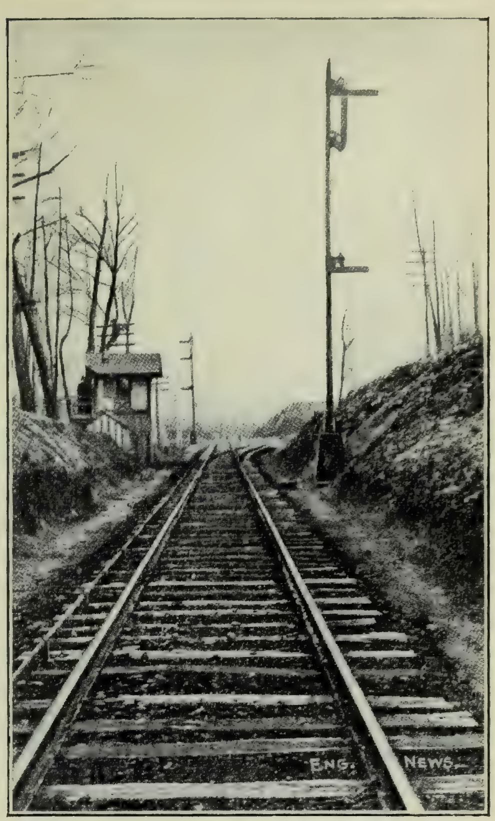
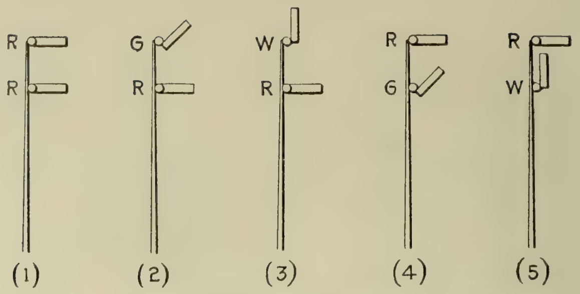
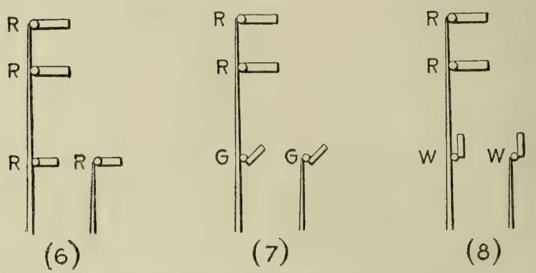


Fig. 2. — Interlocking and block signals at connection of single and double track near Elwyn, Pa. (view looking north).



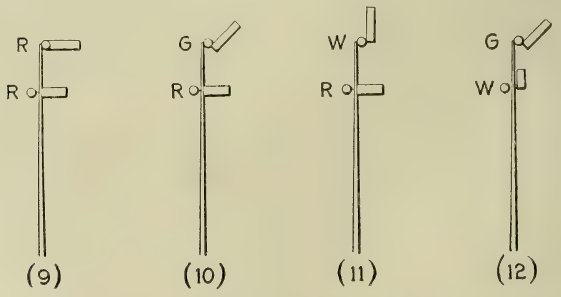
HIGH AND MODERATE SPEEDS.



LOW SPEEDS (ON HIGH AND LOW POSTS).

Class A : “ *Stop and stay* ” *signals for interlocking plants and train orders.*

(1) . . . . = Stop and stay till sigeal indicates proceed.
(2) . . . . = Proceed with caution to next signal, on high speed track.
(3) . . . . = Proceed at high-speed, on high-speed track.
(4) . . . . = Proceed with caution to next signal, on moderate-speed track.
(5) . . . . = Proceed at moderate speed, on moderate-speed track.
(6) . . . . = Stop and stay till signal indicates proceed.
(7) . . . . = Proceed with caution, on low-speed track.
(8) . . . . = Proceed at low-speed, on low-speed track.



Class B : “ *Stop, wait a time, proceed* ”; *for automatic signals (and for distant signals when used for independent indications).*

(9) . . . = Stop, and proceed after waiting prescribed time.
(10) . . . = Proceed to next signal, prepared to stop.
(11) . . . = Proceed at speed; next high-speed signal is at “ caution ” or “ clear ”.
(12) . . . = Proceed at moderate speed; next moderate-speed signal is at “ caution ”. or “ clear ”.

Fig. 3. — Diagram of signal indications on the new block signaling system of the Pennsylvania Railroad.

R = Red light; G = Green light; W = White light.

the case for the battery and mechanism. At one point, the post is carried on a bracket projecting from the side of a cut. In some cases, where the width of right-of-way is limited, the signals for both tracks are mounted upon a steel signal bridge, as shown in figure 1. This is north of Swarthmore and the view is looking northward. The respective indications of the two signals shown in figure 1 are as follows : (1) For southbound (left hand) track; Proceed with caution to next signal. (2) For northbound (right hand) track; Proceed at full speed. Figure 2 shows two single pipe posts at the connection of single and double track, north of Elwyn. Each of these has the additional arm and light for low-speed movements, already noted. The signal in the foreground indicates " Proceed at moderate speed. " The one beyond the interlocking tower (with all three arms horizontal) indicates " Stop and wait until signal gives a clear indication. "

It will be noticed that in figure 1 the two lamps on each post are set on opposite sides of the post, making the upper arm appear longer than the lower arm and showing the two lights 2 feet apart horizontally (center to center of lenses) and 6 feet vertically. This, as already explained, indicates that this signal when at the " stop " position means : Stop, wait the prescribed time and then proceed. In figure 2, both the main (upper) lamps are on the same side of the post, making the arms appear of equal length and showing both lights in a vertical line. This indicates that the signal when at the " stop " position means : " Stop until signal changes to proceed. " It is stated that by day the different positions of lamps and length of arms are easily apparent, while at night the difference is very marked. On the other hand, considerable doubt has been expressed as to the ease of distinguishing the two classes of signals under varying conditions of service and weather, and also doubt as to the advisability of giving so many different indications.

The following is an abstract of a descriptive statement issued by the railway company with regard to this new system of signaling, which is to be used by both the Pennsylvania and the Baltimore & Ohio railways at the new terminal at Washington, D. C. In our editorial columns, we have commented upon this and other developments in railway signal practice.

" Two arms and two lights will be displayed on every high signal. With existing signal arrangements, the number of arms and lights is variable, and depends upon track conditions, so that there may be from one to five on a post. If any arm is broken or a light extinguished, an engineman would probably not notice it; while if there were always two, he would notice the slightest derangement of either of them. A small arm with a light of lower power will, at times, be placed further down on the post or on a separate low post. This, however, will be so far away from the two main signals and of so much smaller size and less powerful light, that it will in no way interfere with the main indications of the two-arm and two-light principle.

" Day indications are given by three positions of the arm in the upper right hand quadrant, and at night each position is indicated by a different colored light. When the arm is horizontal, a red light is displayed; when it is raised to an angle of 45°, a green light is displayed; and when it is still further raised to a vertical position, a white light is displayed. Should the system be generally adopted, however, the colors would probably be red for " stop," yellow for " caution "and green for " clear," thus avoiding the white light altogether. Raising the arm above the horizontal has a distinct advantage over the usual practice of lowering it below the horizontal. Accumulations of ice, sleet, etc., on the arm tend to move it downward; with the new arrangement this would indicate caution or stop, while with the old arrangement the downward movement would indicate either "caution" or "proceed at speed."

"Three classes of signals or signal indications are employed, as follows, the first two alone governing train movements : (A) "Stop and Stay" signals, at which a train, if stopped, must stay until the signal is changed to a position allowing it to proceed. This class includes interlocking, train-order, controlled manual, manual-controlled, and telegraph-block signals. They may be distinguised by the fact that the lights are vertically over one another and the arms appear the same length. (B) "Stop, wait and proceed" signals. A train stopped by signal may proceed after waiting a specified time, even though the signal has not changed and still indicates "stop." This class includes automatic signals (and incidentally distant signals when the latter are used as independent indications). They may be distinguished by the fact that the lower arm and light are not directly under the upper arm and light, but located toward the left, so that the lower arm appears about 2 feet shorter than the upper one, and the lower light shows on the left hand side of the post, while the upper one shows on the right hand side. This staggered relation of the two signals is very noticeable both in the daytime and at night. (C) Signals which give information only and do not authorize or restrict train movements; these include switch indicators (both home and distant), flag-station, water-tank, and stop and slow signals. They are indicated by horizontal lights and special designs for day indications. These signals are all low, and do not interfere with the two-signal principle used on the high poles.

"The signals designate the speed of the trains rather than the routes, at points where interlocking systems are used. (A) The top arm governs the high speed track, provided no crossover movement is included in the route. It indicates proceed at highest speed permissible, modified (of course) by curves or any arbitrary order limiting the speed. (B) The second arm governs medium speed movements, and refers to a divergence from the high-speed routes, such as an easy crossover upon which a speed of 40 or 50 miles an hour is proper. (C) The third arm governs low speed movements; over short crossovers, against traffic, into sidings, etc. This arm is shorter than the other two; it has a short range light and is placed much lower down the post than the two main signals.

The interpretation of the signals is as follows : (1) Red light and horizontal arm, "Stop." (2) Green light (or yellow, as above) and arm at 45°, "Proceed under control to the next signal, which is at 'Stop'." (3) White light (or preferably green) and arm vertical, "Clear, proceed at speed; next signal is at 'clear' or 'caution'."

"All interlocking signal arms remain normally in the horizontal position and at night show a red light. The arms are moved one at a time, so that an engineman could not pass any signal post unless the signal for his particular movement was at "caution" or "clear." The other signals on the post would all be at "stop." On signal posts where no high-speed route exists, the top arm is fixed in the horizontal position and the light is always red. At signal posts where no crossovers or moderate speed routes exist, the second arm is fixed in the horizontal position and the light is always red. The only case when the top and second signals would both be out of horizontal position at the same time, is on an automatic signal post where the lower arm would act as a distant signal for a medium-speed route controlled by an interlocking tower ahead. The diagrams in figure 3 show clearly the signal movements and their meanings.

"Two interlocking plants are included in this installation. These are mechanical, but all signals are electro-pneumatic. Compressed air at 90 lb. per square inch and electricity at 500 volts are furnished from a centrally located plant. The air is transmitted through a $2\,^1/_2$-inch main and the electricity by a No. 6 copper wire. Electricity for operating the track circuits and signals is taken from storage batteries located at the various signals. The batteries are charged in series from the 500-volt supply, eight hours at a time, four nights a week. The batteries have chloride accumulators, each signal pole being supplied with two cells. One cell is used to operate the 16-ohm. signal cylinder magnets and also to feed the track circuit in the rear through a 1-ohm. resistance in connection with the rails. The other cell is in circuit ready for charging. The system of circuits is known as the "polarized wireless," the only wires used being those for the charging line, approach indicators, locks for interlockings, and indication locks of the signals.

"The signal cylinders are tandem and the arms are pulled to the "clear" position by a $^3/_{16}$-inch rod instead of being pushed to that position by a $^3/_4$-inch pipe or 1-inch rod. This new construction saves considerable power. The relays are 5-ohm universal, neutral polar, and the pole changers are pneumatic. It has developed that an ordinary mechanical pole changer would probably be as well suited to the work. All switches are equipped with rotary circuit controllers which shunt the track through two No. 6 wires when switches are open. All boot-leg wires are No. 6, plugged through the web of the rail with channel pins and running direct to battery, relay or pole changer without splices.

"All sidings are equipped with pipe-connected derails, a number of them being of the Hayes type, operated from the main track switch levers. Both ends of the main line crossovers are operated through a switch and lock movement from one ground lever placed in the middle of the crossover tracks. This makes it impossible for careless trainmen to close the switches and clear the signals with a light engine standing on the crossover, and avoiding the use of special circuits to protect this danger point. At first, trainmen unfamiliar with the device used too much force on this lever, and connections were sprung or switch timbers moved. This trouble has practically ended, but in future installations it will be preferable to use this lever merely to lock the points for main track, operating the points from ordinary switchstands. This will make flying switches possible, while insuring that the switches must both be locked before the signals will clear, the circuit closer being operated by the lock itself instead of by the switch.

"All interlocking home signals are power operated, semi-automatic, controlled through stick indicators so arranged that they go to the "stop" position on the passage of train, and cannot be operated again until the train has left the circuit, and the operator has restored his lever to the normal position and again reversed it. Approach indicators and approach locking are provided, taking effect one block in the rear of the distant signal, and so arranged that if the home lever latch has been raised, it cannot be put down to release the machine locking until a period of two minutes has elapsed. The circuits are so arranged that if a portion of the train is left on the approach circuit, the locking automatically releases when the engine enters the home signal circuit. Thus, no hand or time release is required for ordinary trailing drill movements, but if a second train enters the section, the approach locking will become effective as soon as the home signal is cleared for it to proceed.

"The slow hand-release (so called) is really a time release, operated pneumatically and so arranged that it is out of control of the operator. The first application of this ingenious device was made at Morton. Special lamps and brackets were provided, as with those in ordinary use, the lost motion between the lamp socket and bracket were sufficient to allow the lens, in many cases, to angle so much to the side, as to prevent its focusing properly along the track.

" The treatment of the signal at Elwyn (the last one of the system, and on the single track portion) was one of the debatable points. This being the commencement of the block system and track-circuit controlled, three courses were open. The lower arm is the distant for the next signal beyond, and is consequently two-position. If treated as an automatic block signal, the top arm (with track occupied) would also show " stop." Thus a stop signal would be displayed with no warning distant signal in the rear, which violates the principle of advance information for every stop signal. If treated as is the custom at the beginning of an automatic installation on the Pennsylvania Railroad, namely, as a distant signal simply, and not indicating the condition of the track, it obviously should not have the lower arm at " stop " and the top arm normally at " caution," as this is the aspect of the other signals when the next signal is at " stop " and the track is clear. Hence the top arm was fixed at " caution " and the lower arm moves only from " caution " to " clear." This can only be cleared when the track is unoccupied, so that this latter aspect does not conflict with the other signals, and in th enormal indication, two arms at 45° form a different aspect from any other signal displayed.

" It is still an open question whether or not this should be made a " stop and proceed " signal. The arguments in favor are that then the " caution " position would always mean track clear and next signal at " stop " on every signal; and the " stop " indication would never be displayed unless the track were occupied when a " stop " is required. The argument against is the lack of a distant signal, in turn, for this signal.

" Another point has developed in working out the details of the signaling for the new terminal at Washington, where this system is to be installed jointly by the Baltimore & Ohio Railroad and the Pennsylvania Railroad. With all interlocking signals semi-automatic, as in the installation above described, it is impossible to attach cars or switch engines to trains, or to close trains in, except under hand signals. The same difficulty exists on all roads in automatic limits, when the interlocking home signals are semi-automatic. It is now proposed to make the low-speed arm, semi-automatic, from " caution " to " clear " only, and to so arrange the locking and circuits that it may be displayed at " caution " for any route, including the high-speed routes, if the latter are blocked by cars within the interlocking limits.

" In other words, if a high-speed route is clear and next signal at " clear," the top arm will clear. If the track is clear and the next signal at " stop," it will assume the " caution " position. If the track is occupied, the top arm will indicate " stop," but the third or low-speed arm may be shown as " caution." This would combine the safety of the semi-automatic feature for high-speed movements, and the elasticity now attained where (as at outlying interlockings) the signals are not semi-automatic, and hand signals are the exception rather than the rule."

MISCELLANEOUS INFORMATION

[313 .385 (.3)]

1. — The world's railways.

(Archiv für Eisenbahnwesen.)

As in previous years, we print below a table showing the growth of the world's railway lines between 1901 and 1905 and another table exhibiting the cost of their construction.

Table I. — *The railways of the world from the end of 1901 to the end of 1905, and the ratio of mileage to the area and population of each country.*

Reference numbers.	COUNTRIES.	MILEAGE OPEN ON DECEMBER 31,					INCREASE BETWEEN 1901 AND 1905.		Area (square miles).	Thousands of inhabitants.	Mileage open at the end of 1905	
		1901	1902	1903	1904	1905	Total Col. 7 — col. 3.	Percentage $\frac{\text{Col. 8} \times 100}{\text{Col. 3}}$			per 100 square miles.	per 10,000 inhabitants.
1	2	3	4	5	6	7	8	9	10	11	12	13
	I. — Europe.	MILES.					MILES.	P. C.	ROUND FIGURES.			
1	Germany.											
	Prussia	19,677·9	20,173·2	20,414·9	20,822·5	21,268·7	1,590·8	8·1	134,600	34,473	15·8	6·2
	Bavaria	4,209·2	4,245·3	4,400·0	4,603·8	4,667·8	458·6	10·9	29,300	6,176	15·9	7·6
	Saxony	1,792·7	1,826·9	1,847·4	1,847·4	1,854·2	61·5	3·4	5,790	4,202	32·0	4·4
	Wurtemberg	1,174·4	1,184·4	1,209·2	1,232·8	1,232·8	58·4	5·0	7,530	2,169	16·4	5·7
	Baden	1,286·9	1,297·4	1,297·4	1,307·4	1,342·2	55·3	4·3	5,830	1,868	23·0	7·2
	Alsace-Lorraine	1,175·0	1,175·0	1,184·4	1,223·5	1,226·6	51·6	4·4	5,600	1,719	21·9	7·1
	Other States	3,436·9	3,466·0	3,466·0	3.489·1	3,501·5	64·6	1·9	20,120	5,760	17·4	6·1
	Total for Germany	32,753·0	33,368·2	33,819·3	34,526·5	35,093·8	2,340·8	7·1	208,770	56,367	16·7	6·2
2	Austro-Hungary (inclusive of Bosnia and Herzegovna)	23,296·9	23,638·0	24,120·8	24,338·3	24,804·4	1,507·5	6·5	261,210	47,118	9·5	5·3
3	Great Britain and Ireland	22,035·5	22,158·5	22,461·7	22,554·3	22,647·5	612·0	2·8	121,240	41,450	18·7	5·5
4	France	27,127·7	27,747·2	28,100·2	28,442·5	28,873·2	1,745·5	6·4	207,110	38,962	14·0	7·4
5	Russia in Europe and Finland (2,037·5 miles).	31,944·7	32,522·5	33.093·6	33,994·6	34,159·9	2,215·2	6·9	2,081,170	105,542	1·4	3·0
6	Italy	9,824·0	9,906·1	9,966·4	10,014·8	10,118·6	294·6	3·0	110.660	32,475	9·2	3·1
7	Belgium	4,024·0	4,119·1	4,237·2	4,375·2	4,510·0	486·0	12·1	11,390	6,694	39·6	6·5
8	Netherlands and Luxemburg	2,023·9	2,057·4	2.095·3	2,133·2	2,197·8	173·9	8·6	13,750	5,341	15·0	3·5
9	Switzerland	2,429·6	2,483·7	2,575·6	2,640·3	2,665·1	235·5	9·7	15,990	3,325	16·7	8·0
10	Spain	8,469·4	8,556·4	8,606·8	8,782·6	8,966·6	497·2	5·9	191,860	17,961	4·7	4·8
11	Portugal	1,483·9	1,482·7	1,493·8	1,549·7	1,597·6	113·7	7·1	35,750	5,429	4·5	2·9
12	Denmark	1,905·8	1,929·4	1,963·0	2,043·1	2,043·1	137·3	7·2	14,870	2,449	13·7	8·3
13	Norway	1,305·5	1,456·5	1.456·5	1,547·2	1,547·2	241·7	18·5	124,450	2,221	1·3	7·0
14	Sweden	7,200·6	7,566·6	7,697·7	7,815·2	7,881·6	681·0	9·5	172,940	5,136	4·5	15·3
15	Servia	359·1	359·1	359·1	359·1	379·0	19·9	5·5	18,650	2,494	2·1	1·5
16	Roumania	1,970·4	1,974·1	1,974·1	1,974·1	1,974·1	3·7	0·2	50,700	5,913	3·9	3·4
17	Greece	643·1	643·1	643·1	694·7	771·1	128·0	19·9	24,980	2,434	3·1	3·2
18	Turkey in Europe, Bulgaria and Rumelia	1.952·4	1,952·4	1,952·4	1,952·4	1,952·4	..	...	103,090	9,824	1·8	2·0
19	Malta, Jersey, Isle of Man.	68·4	68·4	68·4	68·4	68·4	...	...	420	372	16·1	1·9
	Total for Europe	180,817·9	183,989·4	186,685·0	189,806·2	192,251·4	11,433·5	6·3	3,769,000	391,507	4·8	4·8

Reference numbers.	COUNTRIES.	MILEAGE OPEN ON DECEMBER 31,					INCREASE BETWEEN 1901 AND 1905		Area. (Square miles.)	Thousands of inhabitants.	Mileage open at the end of 1905	
		1901	1902	1903	1904	1905	Total Col. 7 — col. 3.	Percentage Col. 8 × 100 / Col. 3.			per 100 square miles.	per 10,000 inhabitants.
1	2	3	4	5	6	7	8	9	10	11	12	13
	II. — America.	MILES.					MILES.	P. C.	ROUND FIGURES.			
20	Canada.	18,290·4	18,863·9	19,074·0	19,607·2	20,597·0	2,306·6	12·7	3,385,470	5,339	0·6	38·6
21	United States of America, inclusive of Alaska . .	197,198·2	202,432·1	207,935·6	213,862·4	218,417·8	21,219·6	10·8	3,592,930	78,659	6·1	27·8
22	Newfoundland	655·6	655·6	655·6	657·4	666·1	10·5	1·6	42,780	214	1·6	31·1
23	Mexico.	9,602·8	10,357·2	10,357·2	12,077·8	12,227·5	2,624·7	27·3	778,410	14,545	1·6	8·4
24	Cent. America: Guatemala (400·2 miles), Honduras (57·2 mil.), Salvador (96·9 m.), Nicaragua (171·5 m.), Costa Rica (464·8 m.). .	829·5	832·0	945·7	1,003·5	1,190·6	361·1	43·5	...	...	...	...
25	Greater Antilles (Cuba, 1,583·3 mil.; Rep. of Dominica, 116·8 m.; Haïti, 139·8 m.; Jamaica, 185·2 m.; Porto Rico, 200·1 m.) .	1,557·2	1,685·2	2,161·8	2,225·2	2,238·2	681·0	43·7	...	...	...	...
26	Lesser Antilles (Martinique, 139·2 miles; Barbadoes, 57·8 miles; Trinity, 88·2 miles)	277·7	277·7	285·2	285·2	285·2	7·5	2·7	...	...	...	...
27	United States of Columbia.	400·2	400·2	400·2	410·7	410·7	10·5	2·6	513,840	4,500	0·08	0·9
28	Venezuela	633·8	633·8	633·8	633·8	633·8	...	...	403,070	2,445	0·2	2·6
29	British Guiana	74·6	74·6	75·8	75·8	75·8	1·2	1·7	88,650	295	0·08	2·5
30	Dutch Guiana	...	...	...	37·3	37·3	37·3	...	...	...	...	...
31	Ecuador	186·4	186·4	186·4	186·4	186·4	...	...	115,680	1,400	0·2	1·3
32	Peru	1,035·8	1,035·8	1,035·8	1,145·8	1,185·0	149·2	14·4	439,010	4,607	0·3	2·5
33	Bolivia.	621·4	655·6	655·6	701·6	701·6	80·2	12·9	515,160	2,269	0·2	3·1
34	United States of Brazil .	9,195·2	9,195·2	9,368·0	10,406·3	10,442·3	1,247·1	13·6	3,228,470	14,934	0·3	7·0
35	Paraguay	157·2	157·2	157·2	157·2	157·2	...	...	97,730	636	0·2	2·5
36	Uruguay	1,144·0	1,210·5	1,210·5	1,210·5	1,210·5	66·5	5·8	69,000	931	1·8	13·0
37	Chili	2,879·5	2,885·1	2,885·1	2,885·1	2,885·1	5·6	0·2	299,630	3,314	1·0	8·7
38	Argentine Republic . .	10,418·7	10,418·7	11,435·9	12,072·2	12,409·6	1,990·9	19·1	1,114,180	4,894	1·1	25·4
	Total for America. .	255,158·2	261,956·8	269,459·4	279,641·4	285,957·7	30,799·5	12·1	...	...	...	...
	III. — Asia.											
39	Central Russia in Asia .	1,658·4	1,658·4	1,658·4	1,658·4	1,658·4	...	...	214,260	7,740	0·8	2·1
40	Siberia and Manchuria .	5,664·5	5,664·5	5,664·5	5,664·5	5,664·5	...	...	4,833,590	5,773	0·11	9·8
41	China	768·0	942·0	1,175·7	1,227·8	2,246·9	1,478·9	192·6	4,278,550	357,250	0·04	0·06
42	Corea	26·1	37.3	37·3	535·6	663·0	636·9	2,440·5	84,400	9,670	0·8	0·68
43	Japan	4,070·1	4,236·0	4,365·8	4,648·6	4,881·0	810·9	19·9	161,160	46,542	3·1	1·1
44	British India. . . .	25,367·9	25,925·9	26,950·6	27,559·5	28,611·5	3,243·6	12·8	1,956,950	294,905	1·4	1·0
45	Ceylon.	297·0	368·5	391·5	391·5	466·7	169·7	57·1	24,670	3,687	1·9	1·2
46	Persia	33·6	33·6	33·6	33·6	33·6	...	...	635,160	9,000	0·005	0·037
47	Asia Minor and Syria with Cyprus (36 miles). . .	1,715·0	1,715·0	2,008·9	2,152·5	2,221·4	506·4	29·5	686,590	19,568	0·3	1·1
48	Portuguese Indies . . .	51·0	51·0	51·0	51·0	51·0	...	...	1,430	572	3·5	0·9
49	Malay Archipelago (Borneo, Celebes, etc.) . .	272·8	272·8	400·2	446·8	446·8	174·0	63·8	33,280	719	1·3	6·2
50	Dutch Ind. (Java, Sumatra)	1,383·8	1,384·4	1,430·4	1,430·4	1,474·5	90·7	6·6	231,280	29,577	0·6	0·5
51	Siam	237·4	331·8	425·6	446·2	446·2	208·8	88·0	244,410	9,000	0·2	0·5
52	Cochinchina, Camboja, Annam, Tonkin (1,490·1 m.); Pondicherry (59 m.), Malacca (57·2 m.), Philippine Islands (121·8 m.) .	268·4	1,728·1	1,728·1	1,728·1	1,728·1	1,459·7	543·7	...	...	...	...
	Total for Asia. .	41,814·0	44,349·3	46,321·6	47,974·5	50,593·6	8,779·6	21·0	...	...	...	...

Reference numbers.	COUNTRIES.	MILEAGE OPEN ON DECEMBER 31,					INCREASE BETWEEN 1901 AND 1905		Area. (Square miles.)	Thousands of inhabitants.	Mileage open at the end of 1905	
		1901	1902	1903	1904	1905	Total Col. 7 — col. 3.	Percentage Col. 8 × 100 / Col. 3.			per 100 square miles.	per 10,000 inhabitants.
1	2	3	4	5	6	7	8	9	10	11	12	13
	IV. — Africa.	MILES.					MILES.	P. C.	ROUND FIGURES.			
53	Egypt.	2,886·9	2,952·8	2,952·8	3,233·7	3,233·7	346·8	12·0	383,920	9,833	0·8	3·3
54	Algiers and Tunis . .	3,041·1	3,041·1	3,041·1	3,041·1	3,048·5	7·4	0·2	346,500	6,695	0·8	4·5
55	Congo Free State . . .	275·9	275·9	275·9	297·1	297·1	21·2	7·7	...	...	...	...
56	Abyssinia	...	62·1	111·8	111·8	114·3	114·3	...	...	...	...	...
57	British South Africa. Cape Colony .	2,937·3	2,982·0	3,510·8	3,510·8	3,510·8	573·5	19·5	303,800	1,766	1·1	19·9
	Natal . . .	736·3	736·3	736·3	736·3	906·0	169·7	23·0	27,380	778	3·4	11·6
	Transvaal .	1,202·4	1,202·4	1,334·7	1,334·7	1,334·7	132·3	11·0	119,160	867·9	1·1	15·3
	Orange Colony.	596·5	596·5	596·5	596·5	596·5	...	...	50,620	208	1·1	28·6
	Colonies :											
58	Germany (German East Africa, 93·2 miles; German South West Africa, 685·4 miles; Togo, 60·9 miles) . . .	292·0	292·0	292·0	551·8	839·5	547·5	187·4	...	...	...	...
59	England (British East Africa, 581·6 m.; Sierra Leone, 225·5 m ; Gold Coast, 167·8 m.; Lagos, 126·8 miles; Mauritius, 129·9 miles)	895·4	933·9	1,167·6	1,218·6	1,231·6	336·2	37·5	...	...	...	...
60	France (French Soudan, 523·8 m.; French Somali Coast, 77·7 m.; Madagascar, 82 m.; Reunion, 78·9 miles). . .	720·8	720·8	762·4	762·4	762·4	41·6	5·8	...	...	...	...
61	Italy (Erythrea, 47·2 m.).	16·8	16·8	16·8	47·2	47·2	30·4	181·5	...	...	...	...
62	Portugal (Angola, 337·4 m.; Mozambique, 279 m.) .	586·0	616·4	616·4	616·4	616·4	30·4	5·2	...	...	...	...
	Total for Africa. .	14,187·4	14,429·0	15,415·1	16,058·4	16,538·7	2,351·3	16·6	...	...	...	...
	V. — Australia.											
63	New Zealand	2,340·8	2,340·8	2,403·5	2,440·8	2,486·8	146·0	6·2	104,640	830	2·4	30·0
64	Victoria	3,236·8	3,302·0	3,382·8	3,382·8	3,428·2	191·4	5·9	88,420	1,201	3·9	28·5
65	New South Wales. . .	2,844·7	3,024·9	3,158·0	3,280·3	3,450·5	605·8	21·3	308,550	1,370	1·1	25·2
66	South Australia . . .	1,882·1	1,882·1	1,900·8	1,900·8	1,915·7	33·6	1·8	904,130	363	0·2	52·8
67	Queensland.	2,800·6	2,800·6	2,927·3	2,927·3	3,192·6	392·0	14·0	668,520	485	0·5	65·8
68	Tasmania	479·1	618·9	620·2	620·2	620·2	141·1	29·4	26,220	172	2·4	36·0
69	West Australia . . .	1,977·2	1,977·2	2,144·4	2,169·3	2,259·4	282·1	14·3	975,830	412	0·2	54·8
70	Hawaï (24·9 miles) with the isles Maui (6·8 miles) and Oahu (56·5 miles) .	88·2	88·2	88·2	88·2	88·2	...	...	6,830	109	1·3	8·1
	Total for Australia .	15,649·5	16,034·7	16,605·2	16,809·7	17,441·6	1,792·0	11·5	3,083,140	4,942	0·6	35·3
	Recapitulation.											
I	Europe	180,817·9	183,989·4	186,685·0	189,806·2	192,251·4	11,433·5	6·3	3,769,000	391,507	4·8	4·8
II	America	255,158·2	261,956·8	269,459·4	279,641·4	285,957·7	30,799·5	12·1	...	...	...	...
III	Asia	41,814·0	44,349·3	46,321·6	47,974·5	50,593·6	8,779·6	21·0	...	...	...	...
IV	Africa.	14,187·4	14,429·0	15,415·1	16,058·4	16,538·7	2,351·3	17·6	...	...	...	...
V	Australia	15,649·5	16,034·7	16,605·2	16,809·7	17,441·6	1,792·0	11·5	3,083,140	4,942	0·6	35·3
	Total for the whole world.	507,627·0	520,759·2	534,486·3	550,290·2	562,783·0	55,156·0	10·9	...	...	...	...
	Percentage of increase on the preceding year . .	3·4	2·6	2·5	3·1	2·3	...	...	...	...	...	...

Table II.

Construction cost of the railways in different countries.

Reference numbers.	COUNTRIES AND RAILWAY SYSTEMS.	Time	Mileage	Construction capital			
		to which the data as to the cost apply.		total.		per kilometre.	per mile.
	I. — Europe.		Miles.	Marks (round millions).	£	Marks.	£
1	Germany :						
	The entire system.	1905	34,124·5	14,379,000,000	718,950,000	264,981	21,322
2	Austro-Hungary :						
	Austria : The entire system . . .	1905	13,050·3	5,906,000,000	295,300,000	281,212	22,628
	Hungary : The entire system . .	Dec. 31, 1905	11,297·3	3,009,000,000	150,450,000	166,030	13,360
3	France	1903	28,094·6	14,327,000,000	716,350,000	316,870	25,497
4	Belgium :						
	Belgian State	1904	2,483·7	1,719,000,000	85,950,000	430,022	34,602
5	Netherlands :						
	The entire system.	1897	1,653·5	574,000,000	28,700,000	215,614	17,350
6	Great Britain and Ireland :						
	The entire system.	1903	22,430·6	24,901,000,000	1,245,050,000	689,805	55,506
7	Denmark :						
	State railways	1905-1906	1,164·5	231,000,000	11,550,000	123,341	9,925
8	Norway :						
	The entire system.	1905-1906	1,396·2	239,000,000	11,950,000	106,229	8,548
9	Sweden :						
	State railways	1905	2,609·2	502,000,000	25,100,000	119,511	9,617
	Private companies	1903	5,060·5	486,000,000	24,300,000	59,659	4,801
10	Russia (without Finland) :						
	The entire system.	1903	36,683·9	12,242,000,000	612,100,000	207,361	16,685
	Finland : State railways	1905	1,892·7	264,000,000	13,200,000	86,720	6,978
11	Roumania :						
	The entire system.	1904-1905	1,975·4	709,000,000	35,450,000	223,115	17,953
12	Servia :						
	State railways	1904	336·2	85,000,000	4,250,000	157,986	12,712
13	Bulgaria :						
	State railways	1904	751·2	124,000,000	6,200,000	106,466	8,567
14	Italy :						
	The entire system.	1903	10,022·3	4,576,000,000	228,800,000	261,490	21,041
15	Switzerland :						
	The entire system.	1904	2,603·6	1,115,000,000	55,750,000	271,008	21,807
16	Spain :						
	Northern railway	1903	2,271·8	924,000,000	46,200,000	252,841	20,345
	Total and average. .	...	179,902·0	86,312,000,000	4,315,600,000	298,000	23,979

Reference numbers.	COUNTRIES AND RAILWAYS SYSTEMS.	Time	Mileage	Construction capital			
		to which the data as to the cost apply.		total.		per kilometre.	per mile.
	Other parts of the globe.		Miles.	Marks (round millions).	£	Marks.	£
1	United States of America	June 30, 1904	213,862·4	55,495,000,000	2,774,750,000	167,752	13,498
2	Canada	— 30, 1905	20,597·0	5,244,000,000	262,200,000	158,216	12,731
3	Cuba	1905	1,533·6	273,000,000	13,650,000	111,000	8,932
4	Uruguay.	1898-1899	997·3	221,000,000	11,050,000	137,816	11,089
5	Chili : State railways	December 31, 1898	1,375·1	316,000,000	15,800,000	140,454	11,302
6	Argentine Republic	1904	12,072·2	2,354,000,000	117,700,000	121,212	9,753
7	British India	December 31, 1905	28,289·7	4,874,000,000	243,700,000	107,063	8,615
8	Japan.	March 31, 1905	4,693·3	826,000,000	41,300,000	109,298	8,795
9	Siam	1905-1906	263·5	29,000,000	1,450,000	68,948	5,548
10	Java	1893	607·1	124,000,000	6,200,000	135,718	10,921
11	Algiers and Tunis	December 31, 1902	2,269·9	546,000,000	27,300,000	147,433	11,863
12	Cape Colony	— 31, 1905	2,986·4	611,000,000	30,550,000	127,226	10,237
13	Natal	— 31, 1905	817·7	264,000,000	13,200,000	213,471	17,177
14	Sierra-Leone	1903	221·8	20,000,000	1,000,000	53,600	4,313
15	Gold Coast.	1903	170·2	36,000,000	1,800,000	128,000	10,300
16	Lagos.	1903	124·9	18,000,000	900,000	88,000	7,081
17	Colony of New Zealand	March 31, 1905	2,373·7	443,000,000	22,150,000	115,893	9,325
18	— of Victoria	June 30, 1905	3,380·3	842,000,000	42,100,000	154,796	12,456
19	— of New South Wales	— 30, 1905	3,280·3	878,000,000	43,900,000	166,410	13,390
20	— of South Australia	— 30, 1905	1,745·5	277,000,000	13,850,000	98,677	7,940
21	— of Queensland.	— 30, 1905	3,091·4	441,000,000	22,050,000	88,618	7,131
22	— of Tasmania	— 30, 1905	462·3	80,000,000	4,000,000	102,498	8,248
23	— of Western Australia	— 30, 1905	1,605·0	190,000,000	9,500,000	73,594	5,922
	Total and average. . .	...	306,820·6	74,402,000,000	3,720,100,000	151,000	12,150

[656 .257]

2. — The completion of the electric signalling system at Brussels Nord Station.

Figs. 1 and 2, pp. 927 and 928.

(*Chronique des travaux publics.*)

During the night between Saturday, June 8, and Sunday, June 9, the signalling service of the Belgian State Railway set in operation the complete central apparatus for working all the switches and signals of Brussels Nord Station, between the junction at the Rue des Palais and the ends of the lines. Previous partial centralization had already been effected by electric apparatus located in two temporary cabins, built of wood; the one was near Rue Allard crossing, the other near the western foundations of the new cabin (1).

The new electric apparatus is installed in an iron cigar-shaped cabin, which forms a bridge over the lines; it is of a light and graceful shape, although it has a clear span of 51 metres (167 ft. 4 in.) without intermediate support. Not only does the new cabin replace the two temporary cabins, but it also enabled additions to be made to the grid, as may be seen in the figures 1 and 2; the first shows the temporary arrangements in their final stage, the second the present and complete installation.

Every time, up to the present, that works of such importance have been carried out at a large station, the train service there has had to be suspended for some considerable time. Belgium has had the distinction of being the first to work out such a system that not only was it unnecessary to suspend a single passenger train, but also that no passenger was aware of the work which was being carried out.

The scheme first considered had been to suspend the service at Brussels Nord Station, and to receive and despatch the trains at Brussels Allée-Verte, Schaerbeek and Brussels Quartier-Léopold stations, while the alterations were being carried out.

This would have been a very difficult matter, as the accommodation at these minor stations was very limited. An additional difficulty would have been, that however well a new service may be organized, it never works perfectly the first day. These considerations led Mr. Ramaeckers, general secretary, to set the problem which was successfully solved by Mr. Weissenbruch, chief engineer and signalling superintendent.

But before describing the methods adopted, we will give a general description of the installation which is now at work.

The Nord Station consists, as shown diagramatically in figure 2, on the one hand, of fourteen tracks along platforms, and on the other, of seven exit tracks. The latter are marked with Roman figures; there are two tracks for the Western system, two for Ghent, two for Antwerp and one for the Eastern system. The junction of these two sets of tracks, which run in different directions, is effected by a system of points and crossings, and the result forms what is known as the Brussels Nord grid.

We may note that inside the covered station, track 1 is connected with track 2, and track 5 with track 6. Tracks 14 and 15 are dead-ended safety sidings. If the end of

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(1) The electrical appliances for operating the switches and signals at the Brussels Nord Station are of the Siemens and Halske pattern, similar to those at Antwerp Station (central) described in the *Bulletin of the Railway Congress*, No. 8, for August, 1904, p. 651.

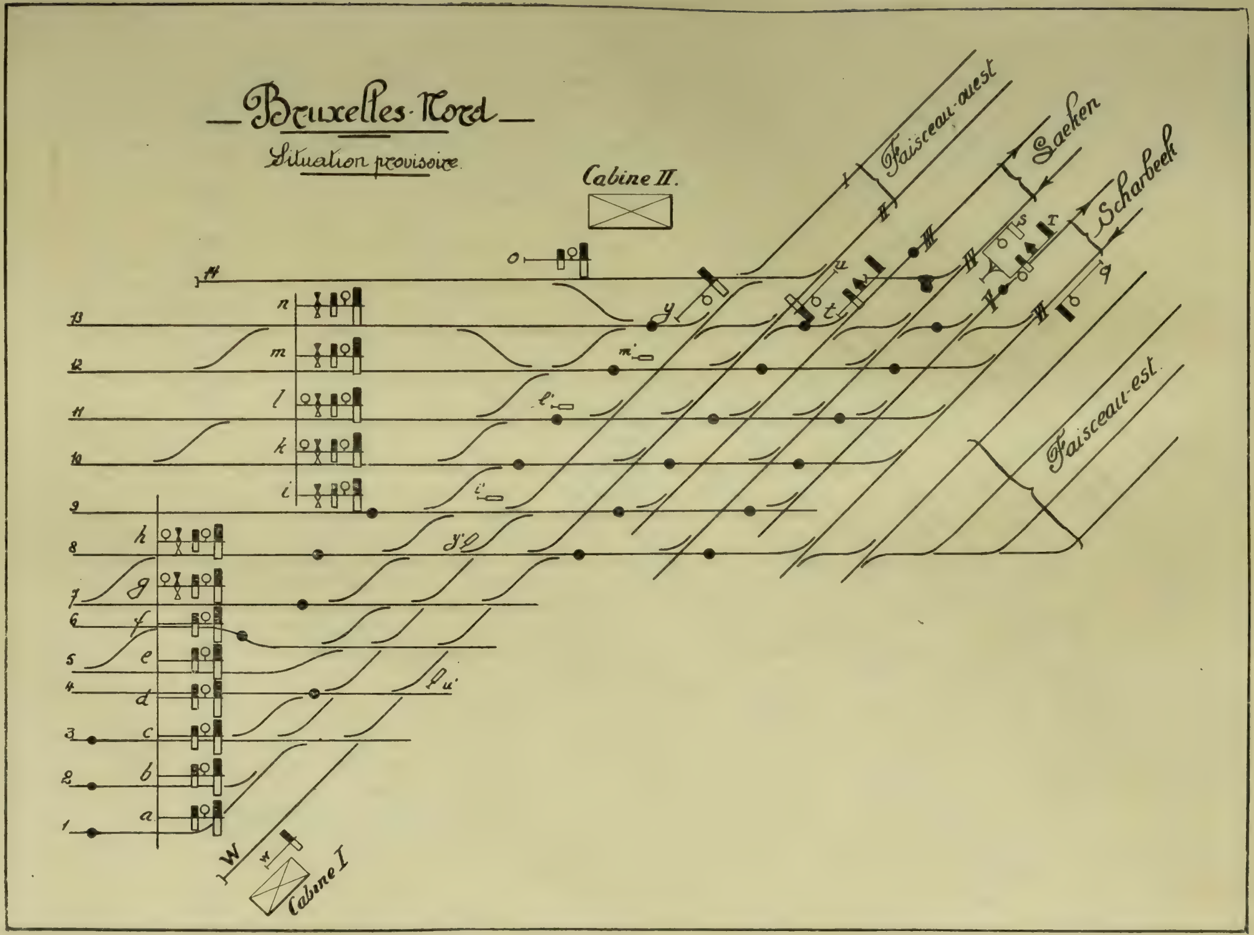


Fig. 1.

Explanation of French terms : Situation provisoire = Temporary arrangement.

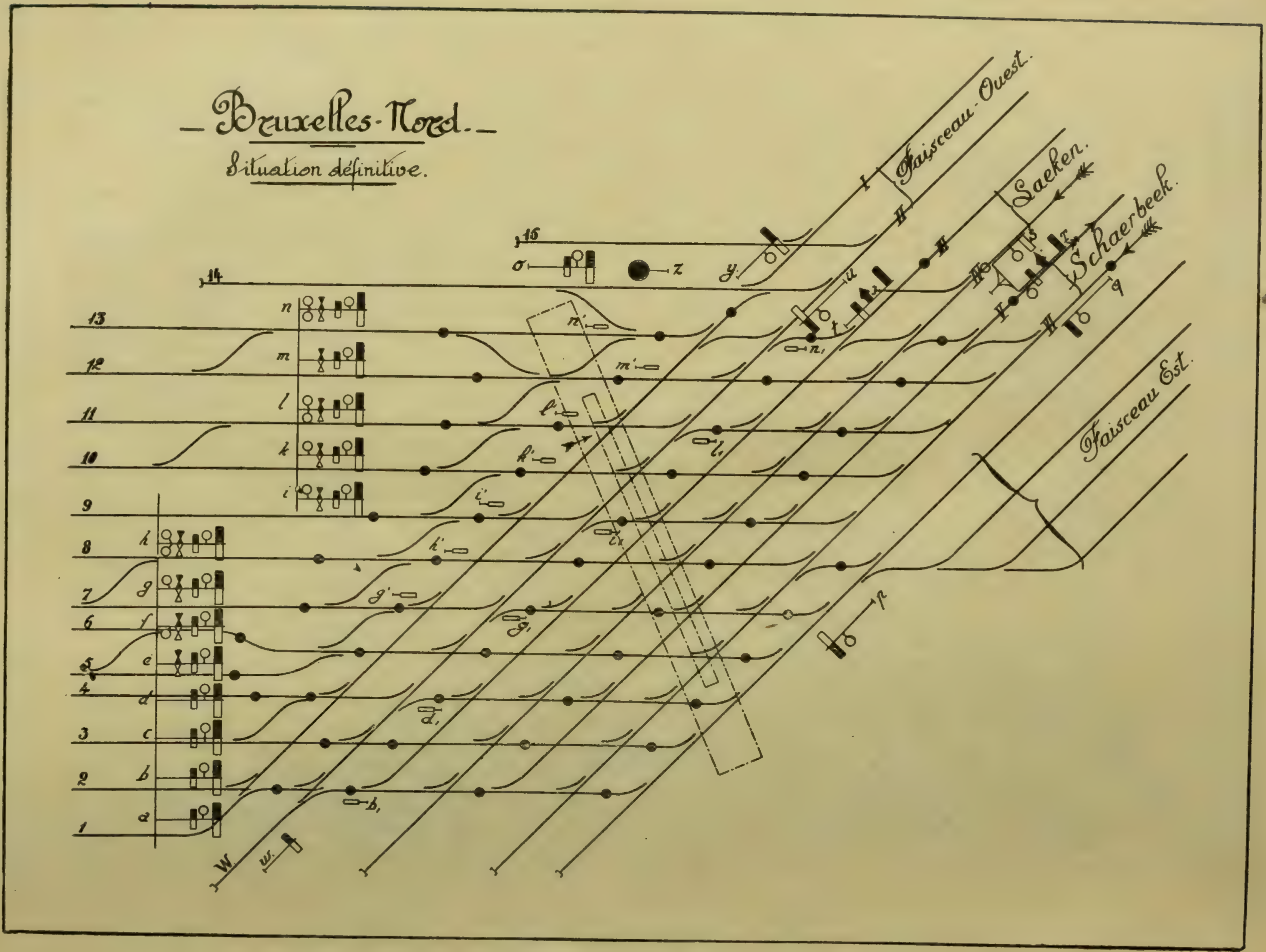


Fig. 2.

Explanation of French terms: Situation définitive = Final arrangement.

track 14 is used for receiving trains, it is because it is connected with track 13. The grid thus consists of 11 receiving tracks, intersecting seven running tracks.

All movements of trains and locomotives and all shunting operations are controlled by electric signals; nevertheless it has been possible to reduce the number of the latter to a strict minimum, by the ingenious devices adopted.

The departure of a train is only controlled by two semaphores or arms; the one is the starting signal on the gantry which is over the ends of the platforms, the other is the route-completion signal located at the exit from the grid.

The indications of these signals are supplemented by numbers which appear as soon as the arm assumes a sloping position. Thus for instance a driver starting from track 8 sees the signal accompanied by a number III if he is going to Laeken, and by a number V if he is going to Schaerbeek. At the same time the upper arm of the signal assumes a sloping position. Inversely, in the case of an arrival, the arm of signal *q*, for instance, assumes a sloping position at the same time that a number (1 to 14) appears indicating alongside which platform the train is going to run.

Before doing this, however, it was necessary to set the route-completion signal of the receiving track in question to " line clear "; this signal is located on one of the two gantries over the ends of the platforms.

Shunting operations inside the grid are carried out in a very similar way, but smaller signals are provided for the purpose.

Some operations can be carried out on what are called *interior* connections without going on to the grid. The smaller cross-shaped arms located on the lower part of the gantries apply to these. These operations are limited by the ground signals *g'*, *h'*, *i'*, *k'*, *l'*, etc., which are normally at line clear and which have to be set to danger before an *interior* operation is begun.

All the switches on a given route are locked as soon as they are set for that route. They are not released until the last car of the train has left the treadle and insulated rail located at the end of the route.

Each route cuts across a certain number of other routes. In order to reduce the number of intersecting routes (and even of routes which might endanger each other if through negligence a signal standing at danger were run through) to a minimum, each route has been divided into several sections, by the use of a corresponding number of treadles. The treadles are shown in the figures by the black spots. If we follow, for instance, track 11, we first find an arrival treadle which does not act for departures, then four departure treadles, the last of which is near the route-completion signal of track V. As the tail end of the train clears in succession each of these treadles, new routes can be made with safety, such routes fouling the sections now cleared by the train.

When a route is made, all routes which might endanger it are switched on to dead-ended sidings. For instance, if a train starts from track 10 in the covered station, it goes on to track 11 and the end of track 10 serves as dead end. A skid is placed on it automatically, so that if a train were to run through its signals and reach that track, it would be stopped before it could affect the train which is starting. Finally, all the rails of the tracks in the covered station and in the grid have electric currents flowing through them and acting on the central apparatus, so that if a car had been forgotten on a route. the signal giving access to that route would remain locked at danger.

The temporary state of affairs, as it existed before June 9, is shown in figure 1. The chief differences, as compared with the present arrangement, are that there were two temporary cabins of wood, and that the grid was not completed. This state of affairs was the necessary result of the successive stages in the re-arrangement of the tracks, such stages being so arranged that the station always remained in use, and that fittings now no longer required could be removed as and when convenient.

During this temporary state of affairs, the signals and switches of the eight first tracks were operated from the first cabin, near Rue Allard, by means of an electric apparatus having 46 levers; it was 4·30 metres (14 ft. 1 $^5/_{16}$ in.) in length and operated by one signal man assisted by a telephone clerk. All the rest of the station was controlled from the second cabin, located near the western foundations of the new cabin; here there were 122 electric levers. The two cabins were slotted reciprocally, that is to say, each of the two cabins required the consent of the other before a common route could be made.

The apparatus in the second cabin was 7·30 metres (23 ft. 11 $^3/_8$ in.) in length and was operated by two signal men and one telephone clerk.

Although the work of the signalmen is much less arduous than formerly, they only work eight hours per day. The apparatus is arranged so that if any mistake is made by one of the staff, only a delay can result, never an accident.

The central apparatus in the present cabin is 22 metres (72 ft. 2 in.) in length, and has 309 levers controlling all the gear of the station; it is operated by three signalmen. As far as we know, this is the largest centralized signalling apparatus, whether electric, hydro-dynamic, pneumatic or electro-pneumatic, in the world. There are three additions above, one at each end and one in the middle, containing a second row of route levers.

The large number of levers is chiefly due to the subdivision of the routes, which so much facilitates the utilization of the grid; each route or each section of a route requires a special lever.

It will also be noted that the interior connections make a large number of operations possible without going on to the grid proper. These consequently involve the presence of a considerable number of route levers.

The arrangement of the levers is such that all the movements in the station can be controlled by one single signalman, the one who is attending to the central part of the apparatus.

Here are grouped the levers of the platform signals, as well as the levers of the routes between the grid and the ends of the platforms.

To the left are the levers of the switches of tracks I, II, III, IV, of the routes and signals of the Western system and of the Ghent lines; to the right, the levers of the switches of tracks V, VI, VII, of the routes and signals of the Eastern system and of the Antwerp lines. By this arrangement the work of the signal men is subdivided to best advantage.

In order to set in operation this extensive apparatus in a very short time, the signalling service used multiple commutators which made it possible to cut, by a simple operation, all the connections of the old cabins, and to make, a few moments later, all the circuits of the new cabin. The work was, however, much less easy than would appear at first sight. It was not a question of mere substitution, as a new part had been added to the grid and a number of routes had consequently to be modified. Then also the new apparatus was to give improved shunting facilities. Now in order to learn how to utilize the latter to best advantage, a certain amount of time was required; it was, therefore, decided to alter the practice at the station as little as possible, to modify the central apparatus provisionally, and to introduce the additional facilities gradually.

The multiple commutator system was also not of altogether general application. Several switches were simultaneously operated by one and the same lever. As a new part was added to the grid, the arrangement of those switches had to be altered. This would have necessitated, in each such case, an internal alteration in the track appliances themselves while in place; a long and delicate operation. In order to avoid it, the plan adopted was to replace the existing appliance, at the last moment, by a new one, ready and arranged. The new apparatus had been connected beforehand with the central cabin, and the substitution had been tested some days before, at some favourable moment when this did not interfere with the service.

The total work consisted in connecting with the new cabin : 133 switches and 1 disk; 22 semaphore poles with altogether 91 arms and 191 route-indicating numbers; 55 route-completion treadles.

The new part of the grid included 35 switches which could be connected directly with the new cabin; in the case of 24 switches, the multiple commutator system could not be applied, and connections had to be made by replacing them by new track appliances.

Connecting all these appliances and testing them one by one in the intervals between trains, took several months and required much skill and care.

The signalmen appointed to operate the new cabin were selected with care, and had had several weeks practice with the apparatus, trying blank operations.

Finally, the signalling service had invented a graphical system of representation of all the movements of trains, locomotives and cars, which took place in the station. This system, similar to that used in the timing of trains, made it possible to determine in advance, with certainty, the modifications to be introduced in the utilization of the track, resulting from the alterations in the routes.

In order to obtain the three clear hours of suspended service necessary, between 1 and 4 a. m., all that was required was to receive and despatch four mail trains at Brussels Allée-Verte Station. Only one of these trains carries passengers, few in number; special arrangements had been made for them. It was also necessary to make, before 1 a. m. and after 4 a. m., some alterations in the shunting operations which are generally carried out between those times.

The only two remaining trains, No. 204, due from Antwerp at 2 h. 1 m., and No. 57, from Herbesthal at 3 h. 4 m., were stopped at the home signal and then brought in by a higher station official.

Thanks to the arrangements made, all the work was completed at the said time, and the new cabin signalled in the first train at 4 h. 5 m. During Sunday, June 9, and successive days, while sundry supplementary and testing work was being done, the train service continued to work regularly. No trains were more than from 2 to 5 minutes late, and all shunting operations worked satisfactorily.

On Thursday, June 13, the service again became quite normal, and has continued so ever since.

[625 .14 (01 & 625 .2 (01]

3. — Wheel and rail of electric railways.

(*The Engineer.*)

We fear that the facts brought out during the recent discussion on wheel and rail at the Institution of Civil Engineers (*see* hereafter) do not redound to the credit of those concerned in the design of the rolling stock of railways worked by electricity. It is admitted on all hands that the rails wear out with disastrous rapidity; but it does not appear that the reason why has gone home to the intelligence of the responsible authorities. The facts lie in a nutshell. While the Metropolitan, for example, was worked by steam locomotives, rails had a life measured by years. The introduction of electric traction has resulted in shortening the life of the rails to months. No one supposes that electricity, *per se*, has any influence. The permanent way has not been altered; the rails are of the same texture, weight and chemical composition as before; the only element changed is the construction of the rolling stock. Common sense leads, of course, directly to the logical conclusion that the rolling stock is in fault, and that to it, and to nothing else, must we look for an explanation of the speedy destruction of the permanent way.

Now, so far as is known, the stock has been designed by men with no traction experience outside tramways. They are electricians first, and railway engineers a long way afterwards. Their contention is that the rail is in fault; but as pointed out by Mr. Burnett, whose long experience as locomotive superintendent of the Metropolitan Railway enables him to speak with authority, the rolling stock is wrong. The bogies are too short, and when the brakes go on they can no longer radiate to a curve. The grinding away of check rails is almost unprecedented; the wheels are far too small and it does not appear that adequate side play has been left between the axle-boxes and the horn plates. We venture to assert that had experienced railway engineers or carriage superintendents been consulted, the rolling stock would not have been just what it is. It may, perhaps, be argued that when electricity is used for traction, only small diameter wheels and short bogies are admissible. If we are to regard present designs as final, then so much the worse for electric traction. Our own view of the question is that it is not electricity, but the designers who are responsible. As one speaker said in the course of the discussion, a fatal mistake was made when tramways were selected as a precedent instead of railways.

Mr. Mallock's paper carries our memory back to an inquiry made more than forty years ago on the Great Eastern Railway to ascertain the area of contact between a driving wheel and a rail. Much difficulty is met with in doing this. The adhesion of locomotives was discussed at great length before the Society of Engineers in November, 1865. The general result was that the area of contact might be taken as about half a square inch with a new tire and a new rail, the load being about eight tons; but the condition of the rail and of the tire so modified results that the only thing certain was that the loading always exceeded the elastic limit of the materials, which therefore ought to crush. Two reasons were brought forward to explain the fact that crushing did not take place in the ordinary sense of the word. The first was practically indentical with that advanced in the recent discussion by Mr. Hopkins, namely, that a suddenly applied and removed stress could be borne, which could not be sustained for an appreciable time. The time element was introduced, and it was said that the metal had not time to give way. This explanation, however, could not deal with the case of an engine standing at rest on the rails. The explanation of the reason why crushing does not then go on will be best understood by supposing a case. Let us imagine that we have a hard rail and that on it we place a small rectangle of steel, with, say, an area of half a square inch — the rectangle is one-fourth of an inch thick. If, now, we applied a load of, say, nine tons to this, deformation will take place, the steel rectangle flattening and spreading. But let us suppose that an excavation is made in the rail head, and the rectangle accurately fitted into this excavation; then deformation cannot occur, because the rectangle, being *encastré* and supported all round, cannot spread. In other words, that portion of a rail which carries the load, whether constant or momentary, is so bound together by the surrounding portions of the rail head, that it cannot give way.

The rails in a tube are spared the effect of hammer blow, and in so far ought to be the better off than when carrying a steam locomotive. That they are not is proved by their short lives. No one in the course of the discussion said anything about slip. It seems to be taken for granted that only steam locomotives slip. Now the slipping on tramways is very heavy, and in damp, greasy weather, it is only by the profuse use of sand that moderate inclines can be surmounted. There is every reason to believe that a great deal of slipping goes on in tubes, and that no one knows anything about it. No doubt the wear and tear of rails in tubes is undergoing careful inquiry; but one of the first steps of that inquiry should consist in fitting counters to the bogies, so that the total number of revolutions made per mile by the driving wheels may be known. A 3-feet wheel makes about 560 revolutions per mile. If it is found that it makes 600, the difference is slip. The test is so easily and cheaply made, and the result would do so much to eliminate or establish the existence of one potent factor, that it is scarcely possible that the experiment will not be made. It appears to us that, in one sense, tube rolling stock has been designed on quite too insignificant a scale. It has been looked upon as a species of toy rather than plant which must do very hard, continuous work. What the cost of maintenance may be there is no means of judging yet, because most of the lines are quite new, and of those that are not, no detailed reports have yet been made public. There is, unfortunately, no reason to believe that they will be moderate. It should, for example, be carefully kept in mind that the wear and tear, which are so excessive, cannot be confined to the rail. Files will not last for ever. Flanges cannot punish check rails and go scot free. The rail will certainly retaliate.

The imperative need of the moment is more flexibility in the rolling stock. To put in harder rails is to treat symptoms, instead of attacking the agency to which the symptoms are due. It would appear that the bogies are too tight to gauge; they are far too short in the wheel base; in some cases they are made without any traversing gear; they are not sufficiently braced diagonally, and the parallelism of their axles is not fully maintained. There ought to be no difficulty in designing bogies on the Bissel truck system, which always gave great satisfaction as fitted to the steam locomotives. The brake gear needs complete remodelling. Much of the worst wear and tear takes place in stations which are on curves. No one during the discussion had a single word to say in favour of the brakes as now fitted. Indeed, not one argument in favour of the existing rolling stock was heard. It was assailed in several quarters, but the attacks were received in silence. No man had anything to say in defence of designs which are doing so much to render themselves intolerable, that nothing, we suspect, but lack of funds prevents the introduction of very substantial alterations.

[62. (06 & 385]

4. — The railways at the conference of the Institution of civil engineers.

(*The Engineer.*)

On Thursday, 20th June, 1907, at the second meeting of section I : Railways, — three papers were read and discussed. The first of these(by Mr. H. R. A. Mallock, F. R. S., was on

The action between wheel and rail.

It possessed no practical value. It is simply an ingenious attempt to arrive by assumption at what goes on when a loaded wheel runs over a rail. To use the author's words : " If a steel cylinder of a certain radius and width rests on a flat steel rail of the same width, and carries a definite load, how much will the cylinder depress the rail and how much will the rail flatten the cylinder? "

In attempting to supply an answer, the author took no account whatever of the fact that the sleepers yield and the rail bends, and gave the following general formulæ connecting the radius of the wheel r, the length of arc a in contact with the rail, the width of the tread b, and the total elastic supporting force of the rail F,

$$a = c_1 \, r^{\frac{2}{3}} \, b^{\frac{1}{3}},$$

$$F = c_2 \, r^{\frac{2}{3}} \, b^{\frac{1}{3}}.$$

If the units are tons and inches, and assuming that 20 tons per square inch is the greatest load which can be laid on a plane of the material without causing permanent set, and that the compression produced by a pressure of 1 ton per square inch is $^1/_{24000}$ of the square root of the area over which it is applied, $c_1 = 0{\cdot}0165$ and $c_2 = 0{\cdot}46$.

The general conclusion at which he arrived is that it is to be expected that wear will be very rapid at first, while the contact areas are small, and will diminish in rate subsequently. A subsequent speaker, however, said that in practice the contrary is the rule.

The discussion which followed showed by its animation that many engineers are interested in the subject. Much of the ground covered the day before in the discussion on Mr. Sandberg's paper was traversed again. Unfortunately, matters were left much where they were. Attention was called to the fact that with electrical stock, the excessive wear was not confined to the rails; the wheels also suffered. Much good was done by greasing the check rail with some coarse oil twice a day. The life of check rails was increased in this way from six months to twenty months. Professor Carus Wilson cited some experiments which he had made with steel cylinders rolling on glass bars. From the results, he deduced that the stresses varied not as some power of the load, as stated by Mr. Mallock, but directly as the load. Further investigation of rails showed that, curiously enough, the top table, which ought to be subject to compressive stress, was really put in tension by the wheels, the action of which was to roll out the rail much as a cook rolls out dough. The microscope revealed multitudes of hair cracks in the table, and if a rail in this condition was turned over, it was certain to break almost immediately by the spreading of one of these cracks. Mr. Hopkins drew attention to the time element. A wire which would only carry 500 lb. of steady stress easily bore 840 lb. for one-thousandth of a second. It would be interesting to know if slow trains did more mischief than fast trains. Mr. Burnett said that the fault was in the rolling stock. The bogies were too short, and the brakes made them rigid. Following speakers called attention to the difference in material of tire and rail, and to the fact that subsoil had no effect. Mr. Benedict found that ridges were bright and hollows dark, and asked if ridges travel along the rail. Then the discussion branched off to tramways. It was said that the electrical stock was modelled on the tramcar, which was a great mistake. Mr. Howley, who has a large experience in electric tram lines in Birmingham, said that he found corrugated rails everywhere. The rail head got rolled out. The remedy lay in the rail. He found that in roaring rails the ratio of carbon to manganese was always low. The cold rolling which went on was due to excess of manganese. At high carbon rail will not roar. When the carbon is under 40 per cent of the manganese roaring occurs.

After a few words of reply by Mr. Mallock, the next paper taken was by Mr. W. Dawson on

A system of audible signalling on railways.

It has been felt by railway officers and by the inspecting officers of the Board of Trade that no device would meet the requirements of the situation unless it would give the driver of a train a distinct audible " danger " signal, and a distinct audible " all right " signal; further, that the device must not depend on electricity to give the " danger " signal, and that should there by chance be any failure in the mechanism, the result must be the sounding of the audible " danger " signal. Such an apparatus has now been designed, and has been in use on the Great Western Railway on a short branch double line for fifteen months, supplementing the ordinary fixed outdoor visible signals as a first test; and as a more advanced experiment, it has been in use for the past five months on a single line — 22 miles long — in total substitution of the semaphore distant signals, which have been removed. During these experimental periods, the apparatus has given great satisfaction, and the drivers and their officers have every confidence in it.

The main features of the system are as under : The parts consist of a slightly arched piece of timber, 40 to 60 feet long, bolted to the sleepers midway between the two running rails, on top of which is bolted a bar of T iron suitably mounted and insulated, the bar being electrically connected by means of a length of telegraph wire to a switch at the signal-box. The bar is electrified by pulling a lever when it is desired to give the " all right " signal. There is no moving part in this ground apparatus. This fixed non-movable sloping bar also serves the purpose of lifting a rod connected with a mechanical device fixed beneath the engine of a standardised design to fit any engine. The lifting of this rod opens a small steam whistle fixed in the cab of the engine when it is desired to give the " danger " signal. To give the " all right " signal, the action set up by the electrified bar on the ground apparatus restrains the whistle from blowing but rings a bell. When the whistle or the bell sounds, either continues do to so until the driver shuts it off, and without any further action on his part, it is ready to produce the same signal again ot the next station.

The discussion was opened by Mr. Jacomb Hood, chief engineer to the London & South-Western Railway. He said the time available for the discussion of so important a subject was too short. The question of substituting audible for visible signals involved very serious issues. Hundreds of attempts had been made to get good automatic signalling, which all broke down in details. If a really trustworthy electric system could be found, it ought to effect an enormous economy. On his line, the cost of maintaining signals was £30,000 a year, or £32 per mile, or $^2/_3 d.$ per train mile. Mr. Ross said that the danger of impact at high speeds might be got over by a system of magnets placed in the track which set the signal apparatus in motion as the train passed. The great difficulty was that while automatic signals told the driver to stop, they did not tell him when to go on again. Colonel Yorke, R. E., Board of Trade, said that audible signals had been tried on the footplate since 1840. He spoke in very high terms of the honesty of purpose and care taken by fogmen. It was a great thing to say that he had never heard of an accident which could be attributed to a fogman. Any automatic system must be kept in constant use summer and winter. If it were not, it would be found wanting in the critical moment. If a system was considered good in the stress and danger of a fog, it must surely be excellent in bright weather. Besides, duplicate systems might prove disconcerting to a driver. He thought that the system described might answer admirably for distant signals, which were caution signals, the train not stopping; but he thought that hand-signalling ought to be retained for home signals. It was most desirable to arrive at the views of drivers. Mr. Blackhall said that they had the Dawson system in use on the Great Western for two years without a single failure. They had now 70 miles of main line fitted. Mr. Marsh, of the London & Brighton Raiway, said that the drivers must be considered first of all. By long practice they acquired a species of instinct which enabled them to locate a signal as a man coming downstairs in the dark in his own house can go straight to the electric light switch. They must keep the human element in view continuously. On the Great Northern, an automatic signal had been tried, apparently with success, but it had to be removed as the drivers " didn't think very much to it." That is, they were accustomed to one system, and did not take kindly to another.

The third and last paper was by Mr. W. Barrington,

On light railway policy.

This paper contained absolutely nothing new or of engineering interest. The sum and substance of the discussion, which few people remained to hear, was that the law and the lawyers were very largely to blame for the smallness of the mileage of light railways in this country. Furthermore it was not certain that light railways gave satisfaction. Unless special and costly expedients were adopted, goods had to be transhipped at junctions with main lines. Farmers would not have this, and preferred to cart their goods to the main line station. Much had been hoped from the use of the highways by running the railway along them. The result had been quite unsatisfactory, for the speed had to be kept down, and if people travelled by rail at all they wanted to go fairly fast. The conclusion was hence reached that there was really no money in light railways, save in a few exceptional cases where two towns were linked together. One, for example, was cited, five miles long, but it had cost £7,000 a mile, and had practically no competitor.

This brought the proceedings of the section to a close. We must add a word of praise to Mr. Galbraith, who made an ideal chairman — the iron hand in the velvet glove. There were times when he had no small difficulty in restraining diffuse speakers who forgot how time pressed; but he never gave offence, and fully earned the thanks of all who came under his rule.

[385. (01 (.57)]

5. — Trans-Siberian railway service.

(From a report by consul-general Thomas Sammons, of Newchwang, Manchuria, based upon recent personal observation.)

(*The Railway and Engineering Review.*)

The time required from Vladivostok to Moscow and St. Petersburg is approximately eleven days. The favorite trains from Moscow to St. Petersburg seem to be those operated at night, the service being somewhat similar to that between Washington and New York, leaving in the evening and arriving in the morning. The time required between Vladivostok and Berlin is about thirteen days, and to Paris and London, fourteen days. The postal trains in Siberia and Russia do not make such fast time as the express trains or *trains de luxe.*

Two *trains de luxe* weekly leave Vladivostok, on Tuesdays and Fridays, and are composed of first and second-class sleeping cars, dining and baggage cars. These trains reach European points *via* Moscow or St. Petersburg. Dinner and lunch are served in family style. Breakfast *à la carte* with good coffee, tea, eggs, omelets, bread, etc., served at reasonable prices. Luncheon and dinner cost 50 and 75 cents, respectively. Special dishes with wines, tea, etc., are charged for separately. Sleeping car accommodations are comfortable, but toilet facilities are not as luxurious as other accommodations. Tourists should carry an ample supply of towels, soap, etc.

Well-regulated restaurants at the principal stations are supplied with wholesome food. Parties of four, occupying a double second-class coupe, four berths, frequently find second-class accommodation satisfactory. Parties of less than four in second-class cars, where there are, as a rule, four berths to the coupé, reports finding in some instances, travellers assigned to share the coupé uncongenial or unsatisfactory in many ways. This may hold true, also, in first-class sleeping cars, where there are facilities, as a rule, for but two berths to a coupé. By opening adjustable doors, families or parties of four or six can usually be assigned to connecting compartments on first-class sleepers. This can not be done as a rule in the second-class sleepers where there are four berths to a coupé. The Trans-Siberian sleeper is divided into compartments, with a passage-way along the side of the car. Russian berths are more commodious than those in America, the cars being larger and the railway gauge being wider. Many Russians, on account of their physical proportions, require greater berth space than is usually requisite for comfort on American roads. The Wagon Lits service (similar to the American Pullman service) can be had west of Irkutsk, the extra charge for berths, etc., being nominal, equivalent to $15·35 per berth and accommodations aboard the Wagon Lits train, first-class sleeper, etc., for the seven day ride from Irkutsk to Moscow. The Wagon Lits trains connect at Irkutsk with the Chinese Eastern Railway trains, which are operated between Irkutsk and Vladivostok. Tourists usually favor the Wagon Lits trains wes tof and the *trains de luxe* east of Irkutsk. When there are no women or inexperienced travellers in parties, Russian postal trains may be found satisfactory. Persons desiring to study the country and conditions carefully, may find the slower trains more to their purpose.

Including berths on sleeping cars operated in connection with the Chinese Eastern Railway and Russian trains, but not including the extra referred to when riding on the Wagon Lits trains west of Irkutsk, first-class fare, Vladivostok to Moscow, is $128·74; second-slass, $84·31; to St. Petersburg, $134 and $88, respectively; Harbin to Moscow, $107·82 and $71·30, respectively; Moscow or St. Petersburg to Berlin, approximately, $26, and to Paris or London, about $45. For extra accommodations, a higher rate may be paid west of Moscow and St. Petersburg, the Wagon Lits express trains being the most luxurious and fast, although the regular Russian, German, and French trains are entirely satisfactory. It is well to make reservations in advance in order to secure desired accommodation. This is particularly true in going west *via* Japanese or Chinese points. American or Russian members of the consular service may be consulted as to reliable booking agencies in the Far East.

One pood or 36 pounds of baggage is allowed free. Excess baggage is charged for at the rate of $1·32 per 10 pounds from Vladivostok to Moscow and $1·18 per 10 pounds from Harbin to Moscow. Russian sleeping cars, also Wagon Lits sleeping cars in Siberia and Russia, are decidedly roomy and twice the number of packages and grips can be accommodated as on the ordinary Pullman. Passengers on the Trans-Siberian railway route are liberally provided with hand baggage, and this is rendered desirable and necessary on account of the great distance and time required to make the trip. Many second and some first-class passengers on the *trains de luxe* carry a supply of tea, sweets, crackers, etc., together with a small teapot, and by paying the car porter a small fee, usually 5 or 10 cents, are supplied with hot water when tea and light refreshments are desired in the coupé. A small steamer trunk can frequently be carried on a wire shelf over the passage-way of the compartment sleeping cars. Over this passage-way, on some of the Wagon Lits cars on the Trans-Siberian route, a number of grips and small boxes can be stored from inside the coupé.

Baggage should be given close personal attention. Russian station porters and car porters are helpful and usually faithful in assisting in moving and storing baggage. It is well to note the number of the station porter as it appears on the front of his cap. Of a total of nine small pieces of hand luggage and two small steamer trunks or English cabin boxes that accompanied our party, none were lost *en route*. There are, however, numerous complaints of baggage being lost and of small articles of personal apparel and money being stolen in or about Siberian railway stations. Some instances of these complaints, however, were traced to causes that might ordinarily result in the separation of the traveller from his money or goods in America or elsewhere throughout the world.

English-speaking guides can be used to advantage. It can scarcely be considered advisable to attempt anything like satisfactory sight-seeing trips at Vladivostok, Harbin, Moscow or St. Petersburg, unless some member of the party speaks Russian or a reputable and reliably recommended Englisch-speaking Russian guide be employed. Guides are usually paid $2·50 to $3 per day, including meals and expenses while on duty.

A knowledge of French is very helpful, also a dictionary in Russian, German, and French, as well as English. These languages are usually spoken, however, by the train or dining car conductors. On the Chinese Eastern Railway east of Irkutsk, a speaking knowledge of Russian, French or German, in addition to English, is more requisite, although in most instances there are to be found travellers who speak several languages. A great aid to most travellers who speak only English. The Russian word for "please" is so frequently used as to become familiar to travellers, and should be included in the traveller's prearranged vocabulary with a few dining and sleeping car necessaries, written plainly in English and Russian.

When travellers proceed westward over the Trans-Siberian Railway it is possible to arrange to go directly from the steamer at Vladivostok to the *train de luxe*. This is sometimes done to avoid unsatisfactory hotel accommodation which has been until quite recently poor in the Siberian-Manchurian section. There are hotels to be found at most of the various Chinese, Japanese, and some of the Korean ports that serve foreign or English meals. Prices average $3 to $5 per day, American plan. The European plan is less. Improvements are anticipated. Newchwang, Port Arthur, Tairen (Dalny), Seoul and Fusan (Korea) have limited accommodations that are ordinarily satisfactory. Improvements are promised as the volume of travel warrants. At some of the smaller places, the traveller finds that the homes of foreign missionaries afford the only possible accommodation to be had. At Moscow and St. Petersburg, there are several good hotels that are patronized by foreigners and where English-speaking clerks are employed.

There are regular lines of steamers between Japanese and Chinese, as well as Korean, ports and Vladivostok. The quickest route for those travelling to Europe *via* the Trans-Siberian Railway, and proceeding from America, would be to take a steamer at Tsuruga, Japan, that connects with the Trans-Siberian Railway at Vladivostok. By leaving Tsuruga ad midnight on Saturday, connection is made with the *train de luxe* leaving Vladivostok on the following Tuesday. The charge for first-class passage on these steamers is approximately $15. Steamers can also be boarded at Nagasaki, Japan; Shanghai, China; Fusan, Korea, and other Japanese and Chinese ports for Vladivostok, and pending satisfactory hotel accommodations, passengers may arrange with the captains of such steamers to remain on board until the Tuesdays, and Fridays' trains depart for the west.

Travellers may also connect with the Trans-Siberian Railway at Harbin after proceeding north from Chinese ports to Newchwang or Tairen (Dalny), thence over the Japanese rail lines to Kwanchengtze, and from there by the Russian line to Harbin. This connection may also be made *via* the Shanghai Yangtse River steamers to Hankow, thence by rail to Peking and Newchwang. Harbin can be reached from Newchwang or Dalny in about two days, changing cars at Kwanchengtze, which is about 200 miles south of Harbin and approximately the same distance north of Mukden. The railway accommodations in Manchuria south of Harbin have until recently not been of a nature that is inviting to travellers who are accustomed to the luxuries of modern railway facilities. The Newchwang-Peking-Hankow section, however, can be travelled with comparative comfort, there being a dining-car service on the Peking-Newchwang line, and both dining and sleeping cars on the Peking-Hankow section. By the fast train, the distance from Hankow to Peking is to be covered in thirty-six hours; by slow train in three, formerly four, days. Peking to Newchwang requires two days, trains not being operated at night, and passengers lodging in a hotel at Shanhaikwan, where the Great Wall of China reaches the sea.

Passports are required and should be viséd by a Russian consul at one of the oriental ports of departure. Passports are usually examined and stamped by the local authorities at hotels *en route* where travellers stay. In some cases, a small charge is made for giving attention to this matter, which is included in the hotel bill.

If tickets are purchased at Vladivostok, roubles will be used in settlement. The rouble is used throughout the Trans-Siberian Railway route. American, Japanese, or Chinese money can be exchanged at Vladivostok, a commission for this service being charged. For Japanese rail lines, Japanese money will be necessary. For larger sums, a letter of credit is desirable in drawing funds from Japanese or Russian banks. The yen, Mexican dollar, and rouble are accepted in small commercial transactions as being of the approximate value of 50 cents gold. All prices herein given are in gold dollars.

It is possible to reach the Trans-Siberian Railway *via* Korea. From Fusan, in southern Korea, Seoul can be reached by a daylight run of about twelve hours. Thence *via* rail to Chemulpo and steamer to Tairen (Dalny) for Port Arthur, Mukden and Harbin, which latter place, as well as Mukden, may be reached, as stated above, by the Newchwang and Port Arthur lines. From Seoul travelers can also proceed to Wiju, Korea, and Antung, Manchuria, on the Yalu River, by the Fusan-Seoul-Wiju Railway, which is of the American standard gauge and has cars of American pattern, a buffet lunch being served between Fusan and Seoul. At Antung the Japanese narrow (2 $^1/_2$ foot) gauge line affords accommodations sufficient for experienced foreign male travellers. The distance from Antung to Mukden (187 miles) is covered in two days, the night being spent at a midway station which had not been, at a recent date, provided with foreign hotel accommodation. At Mukden, connections can be made with the Japanese line (3-foot gauge) to Kwanchengtze (no foreign hotel accommodations at a recent date) and thence by the Russian section daily to Harbin.

It would be decidedly inconvenient, with such facilities as were available until quite recently, for a woman to make the trip by rail from Antung to Mukden. Trains on this line, as well as on the Newchwang-Port Arthur-Tarien (Dalny) lines to Mukden and Kwanchengtze, were not at a recent date provided with lavatories or toilet accommodations.

A Japanese steamship and rail line offers exceptionally inviting accommodation between Japanese and Korean points. As conditions change and more satisfactory facilities are afforded for travellers in Manchuria, information may be had through the American consular service.

[625 .4]

6. — The scheme for an overhead railway in Berlin.

(*Zeitung des Vereins.*)

The overhead railway devised to traverse the capital of Germany from north to south, between Gesundbrunnen and Rixdorf, was made the subject of an exhibition organized for the sake of those concerned, by the Nuremberg Continental Electrical Company, at the Berlin Town Hall. We have discussed this question at various times, especially in a fairly long article that appeared in our 79th issue of the *Zeitung* for 1906, commenting upon the fact that from thenceforward the overhead railway had assumed a preponderating position among the means of rapid transport in great cities. The *Archiv für Post und Telegraphen* has recently published a full analysis of this Berlin scheme from the pen of Mr. Böttcher, inspector of postal services. We borrow from that article the following data and opinions :

" Everybody agrees in acknowledging that it is really an urgent necessity to connect the north and south of Berlin directly with the centre of the city. Travelling from the western and eastern suburbs, one can easily and without change reach the centre by the Ringbahn (circular railway) and the Stadtbahn (metropolitan railway) ; on the other hand, to get there on leaving the northern or southern suburbs, means making a long and complicated journey. This explains why the construction of the rapid transit lines in question, is of so much importance for the future development of the suburban districts towards the north and south of Berlin which have so long been neglected from the standpoint of travelling facilities...

" As regards the route surveyed, we have already supplied details in our No. 83, for 1905, and No. 18, for 1906, and so we shall content ourselves with referring our readers to these articles. Where the new line is to meet the Stadt- und Ringbahn and the Hoch- und Untergrundbahn (electric overhead and underground line) stations, its platforms will be conveniently connected with those of these lines. The whole journey will occupy twenty-two minutes. The intention is to run trains every five minutes during the busy times of the day, and every ten minutes in the early and late parts of the day. As on the Barmen-Elberfeld lines, the normal traffic will be accommodated by single cars run at the above intervals. If the traffc is extra heavy, the trains would follow each other at two minute intervals... At ordinary times, on the projected line, all the traffic would be carried on in the forward direction. Consequently, the sheds at the two ends of the line will be supplied with racket-shaped curves. In addition, provision has been made between the sheds and the terminal stations (at Rixdorf and Gesundbrunnen) for turn-tables with sidings for inspecting the machinery of the cars. The shed tracks which connect with these sidings, are only to be used when the service is suspended or when the length of the trains has to be altered. In the latter case, the incoming train goes direct into the shed and is replaced by another train which comes out with the requisite number of carriages. Thanks to this method of organisation, the trains will follow one another safely and quickly.

" The cost of construction is estimated at 3 million marks per kilometre (£241,400 per mile), or altogether, for the 12 kilometres (7·5 miles) 36 million marks (£1,800,000). There will be one class only. Tickets will cost 10 pfennigs (1·2*d.*) for five stations from the point of departure, and 15 pfennigs (1·8*d.*) for any greater distance.

" As regards the present position of the project, the matter, having so far been treated with much hesitancy by the Berlin municipal authorities, has nevertheless made a great step forwards. After lengthy preliminaries, the municipal traffic commission has lately authorized the promoter to build the Brunnenstrasse trial section under the conditions previously enacted. According to these conditions, 40 metres (44 yards) of the projected railway will be constructed in this street, between Invaliden-Strasse and Lothringer-Strasse, on iron supports and at the real height of the future line. Moreover, 60 metres (66 yards), will be built, at a height of 3 metres (9 ft. 10 in.), with timber trestles, so that altogether there will be a trial section of 100 metres (109 yards), which it is supposed will be sufficient to judge how far in this busy street an installation of this kind is compatible with the ordinary circulation of wheeled vehicles and pedestrians. It is to be hoped that the apprehensions expressed by the traffic commissioners and subsequently by the lay press, with reference to the dangers entailed by intermediate pillars, will be found unjustified. The intention is to surround them with a curb and so stave off the shocks of road vehicles. The trial section will be ample to show whether this will be sufficient protection. In any case, the overhead line is now fairly started and we wish it every success."

[625 .245]

7. — New air brake instruction car : Chicago, Burlington & Quincy Railway.

Figs. 3 to 8, pp. 943 to 945.

(*Railway Master Mechanic.*)

The new air brake instruction car just completed at the Aurora shops of the Chicago, Burlington & Quincy Railway is noteworthy as representing the latest development in cars of this type. The originality of design and general arrangement, with the handsome finish and appearance, combine to make the car an ideal one for instruction purposes.

The car body which was converted from a mail car is divided into three compartments : an office 12 feet long, a class room 41 feet long and a boiler room 9 feet long. The office is arranged with a roll top desk, upper and lower berths, wardrobe and toilet room. Above the desk, is placed a triplex gauge showing train line, signal line and brake cylinder pressures under the car, for the purpose of showing the manner in which the train brakes were handled while the car is in transit.

Te boiler room contains a 46 inch vertical boiler, carrying 200 pounds pressure and is equipped with shaking rates, and extension smoke stack. A 9 $^1/_2$-inch air pump is attached to the boiler for supplying air to the car, and connections are also made so that air can be furnished from a locomotive when coupled to the car. A Baker heater is placed in the rear of the room for heating. The two ton coal box and 600 gallon water tank are placed in the forward end of the boiler room behind the two rows of brake cylinders.

The instruction room is a compartment 41 feet long with space at the forward end for 18 men seated on folding chairs, and is provided with a complete assortment of the latest air brake equipment. The freight brake cylinders are arranged vertically, in two rows on each side of the car, which converge towards the boiler room end, bringing every piston rod in view. The value of this feature is apparent to those who are familiar with the average air brake car. There is an equipment of 52 brake cylinders, consisting of 36 Westinghouse 8 by 12 inch freight brakes, 11 New York 8 by 12 inch freight brakes, 2 Westinghouse 10 by 12 inch passenger brakes, 1 Westinghouse 8 by 12 inch tender brakes, and 2 Westinghouse 10 by 10 inch driver brakes. The brake cylinders, main and auxiliary reservoirs, triple valves, retaining valves, pumps, brake valves with all necessary piping and fittings are painted in the standard Westinghouse colors, so that instruction is rendered much more simple and effective.

One of the novel features of the car is the substitution of 45 10-inch by 12-inch equalizing reservoirs for the train line piping of 45 freight cars. It has been found by experiments on the Chicago & Northwestern railway that the operation of the brakes is not affected by substituting the reservoirs for the train line. This method saves a great deal of space

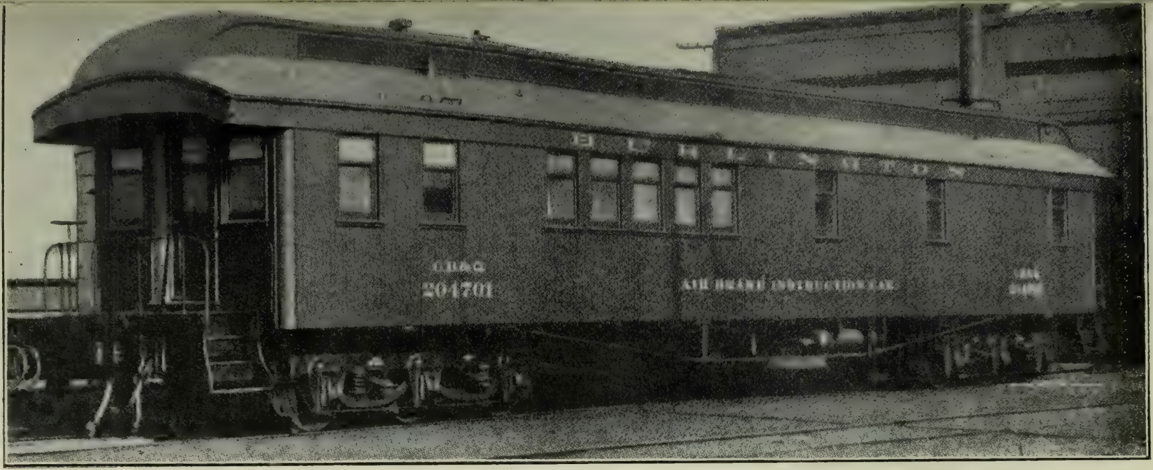


Fig. 3. — The new air brake instruction car, Chicago, Burlington & Quincy Railway.

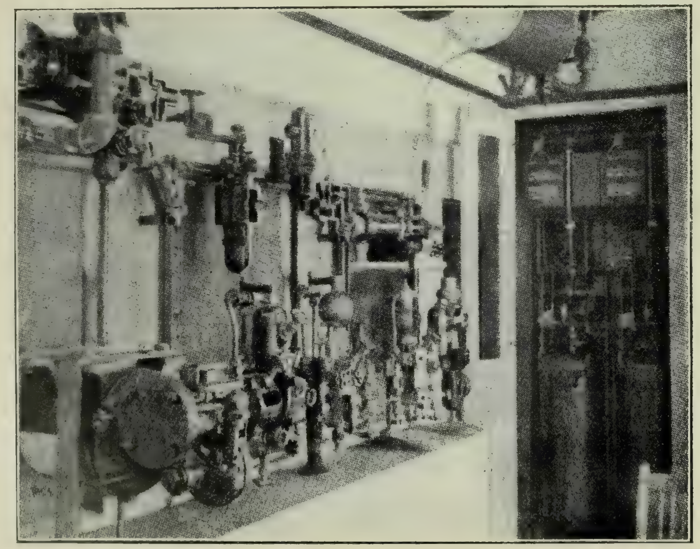


Fig. 4. — Corner in the class room of the new air brake instruction car, Chicago, Burlington & Quincy Railway, showing sectional models of distributing valve, injectors, lubricators, etc., with closet containing acetylene gas apparatus.

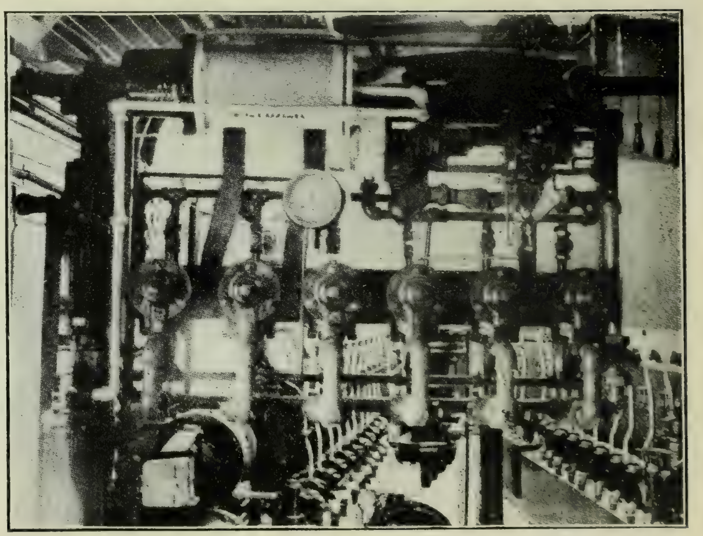


Fig. 5. — Rack on which defective triple valves are mounted, swung out from the wall facing the class room for demonstrating purposes. — New air brake instruction car, Chicago, Burlington & Quincy Railway.

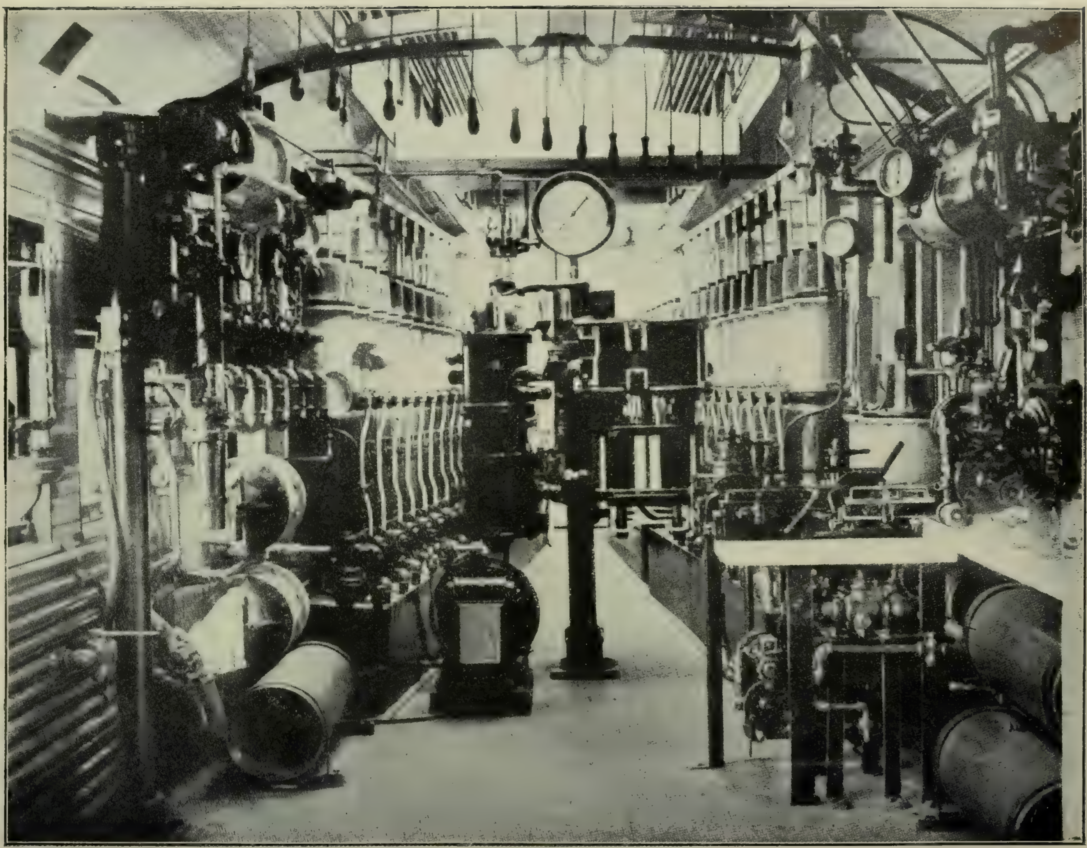


Fig. 6. — Interior view of new air brake instruction car, Chicago, Burlington & Quincy Railway. Looking from the class room. On the left, swinging crane with defective triples; in the center, swinging post with sectional models of air pumps, and 12-inch air gauge above; whistle signal handles in upper foreground, behind which is seen the chart box. On the right are the brake valves, etc. The converging rows of brake cylinders are plainly shown, with iron casings below for the train line reservoirs. On the floor in the foreground is the electric headlight turbine for instruction and lighting purposes.

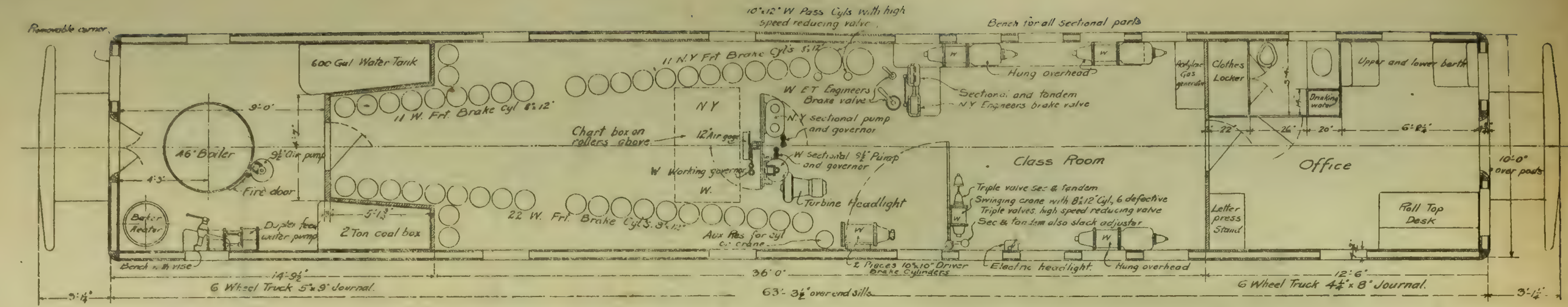

Removable corner
10"x12" W Pass Cyls with high speed reducing valve
Bench for all Sectional parts
600 Gal Water Tank
11 N.Y Frt Brake Cyls 8"x12"
11 W. Frt. Brake Cyl 8"x12"
N Y
W E T Engineers Brake valve
Sectional and tandem N Y Engineers brake valve
Hung overhead
N.Y Sectional pump and governor
Chart box on rollers above
12 Air gage
W Working governor
W.
W Sectional 9½" Pump and governor
Turbine Headlight
46" Boiler
9½" Air pump
Fire door
Boiler Heater
Duplex feed water pump
2 Ton coal box
22 W. Frt. Brake Cyls 8"x12"
Aux Res for cyl on crane
Class Room
Triple valve Sec & tandem
Swinging crane with 8"x12" Cyl, 6 defective Triple valves, high speed reducing valve
Sec & tandem also slack adjuster
2 Pieces 10"x10" Driver Brake Cylinders
Electric headlight
Hung overhead
Acetylene Gas generator
Clothes Locker
Drinking water
Upper and lower berth
Office
Letter press Stand
Roll Top Desk
Bench with vise
9'-0"
4'-3"
5'-1¾"
14'-9½"
36'-0"
12'-6"
22"
26"
20"
6'-8¼"
10'-0" over posts
3'-1¼"
6 Wheel Truck 5"x9" Journal
63'-3½" over end sills
6 Wheel Truck 4¼"x8" Journal

Fig. 7. — Floor plan of the new air brake instruction car, Chicago, Burlington & Quincy Railway. Showing arrangement of compartments and distribution of equipment.

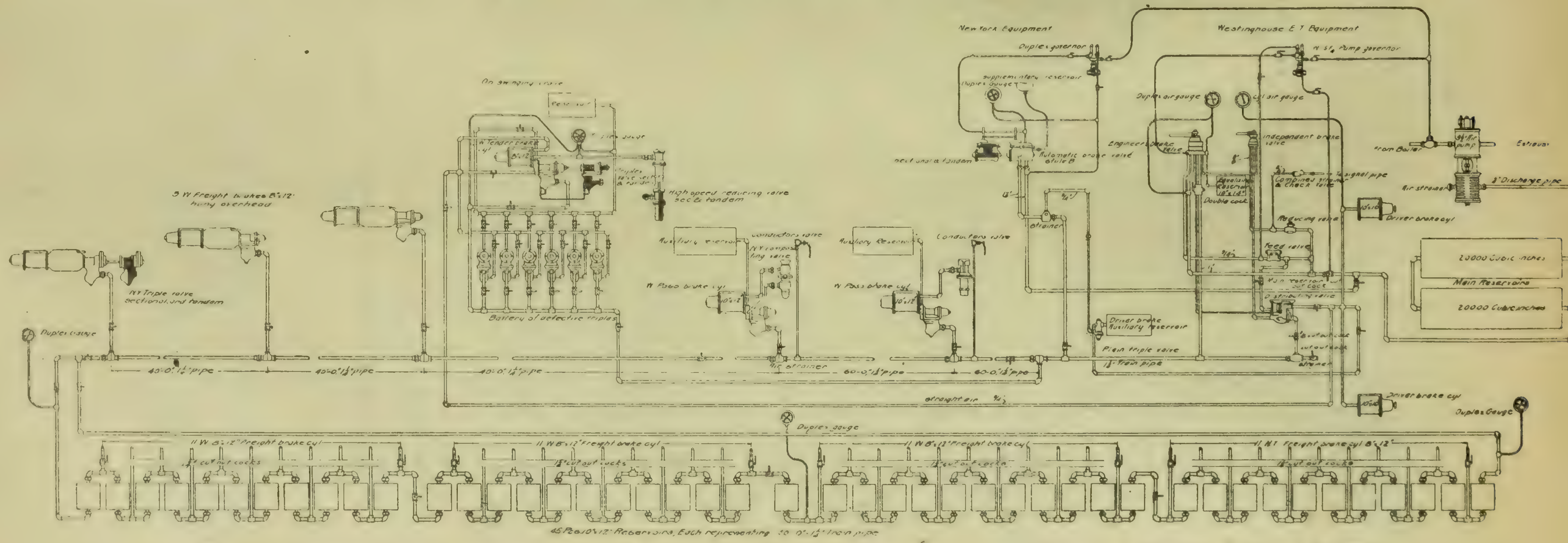


Fig. 8. — Diagram of piping and arrangement of equipment. — New air brake instruction car, Chicago, Burlington & Quincy Railway.

and weight. The reservoirs are placed on the floor directly beneath the brake cylinders and are enclosed in a galvanized iron casing as shown in the illustration. The triple valves are attached by means of a special elbow which brings them into horizontal position, the same as under a car.

For special purposes, three of the brake cylinders are hung horizontally below the lower deck and the tender brake cylinder is bolted to a swinging crane on which are also mounted six triple valves having various defects, any one of which can be connected with the cylinder for the purpose of showing the effect they produce on action of the brake. The illustrations show the crane in place against the wall and also swung out at an angle of 90 degrees, facing the class room for the purpose of instruction. The brakes are connected up, so that they can be operated in various combinations and by either the Westinghouse or New York systems.

The air signal apparatus consists of a complete equipment of 14 sixty foot cars, the piping being placed on each side of the skylight, with the signal cord handles arranged for convenience of operation.

Directly in front of the class room, are mounted sectional models of Westinghouse and New York air pumps, on a swinging post which allows the pumps to be turned in any position for the purpose of instruction. When not in use, they are turned edgeways in order to leave an unobstructed view of the brake cylinders. In order to show the train line reductions more clearly when demonstrating to a class, a 12-inch gauge is mounted above the pumps in plain view. The colored air brake charts are mounted on spring rollers in a movable case which is placed on guides each side of the deck. When in use, the case is slid ahead close to the class, the doors unlatched and the charts pulled down in plain view. When not in use, the case is moved back beyond the pumps out of the way.

The various appliances and equipment are arranged around the class room so that everything is in full view. On the right hand side, are sectional models of brake valves, lubricators, injectors and steam heat apparatus, with electric headlight, etc., on the other side. For purposes of instruction and also for lighting, the car is equipped with Pyle electric headlight outfit and Adlake acetylene system complete. Natural lighting is well provided for by windows and long skylights in the deck, with 26 electric lights and 22 acetylene jets for artificial illumination.

We are indebted to Mr. F. H. Clark, general superintendent of motive power, and Mr. A. Forsyth, superintendent of shops, for the illustrations presented.

[621 .152.3]

8. — Four-cylinder compound locomotive for the Italian State railroads.

Figs. 9 to 15, p. 949 to 953.

(*Railroad Gazette.*)

There was exhibited at the recent Milan Exposition, a locomotive built for the Italian State Railroads that possesses so many variations from standard practice that it may fairly be classed as an experiment. The machine was built by the Societa Italiana Ernesto Breda, Milan, and is one of the most powerful locomotives built, up to this time, for the state system. It is intended for service in express passenger work between Milan and Venice. It is a four-cylinder compound, with six wheels coupled, and, as will be seen from the reproduction of the photograph (fig. 9), is designed to run normally with the cab to the front. The four-wheeled bogie truck is set beneath the rear end of the boiler, and has a wheel base of 7 ft. 8 $^1/_2$ in. A peculiarity of this truck is that the center plate is not situated midway between the wheels, but the space is so divided that the distance from the outer wheel to the center plate is 49·2 inches and 43·3 inches to the wheel beneath the throat. As the driving wheels are 75·59 inches in diameter, the rigid wheel base is carried out nearly to the end of the smoke-box, making it necessary to set the cylinders well out to the rear beyond the smoke-box, and to carry them on an extension to the frames. The arrangement of these cylinders is even more novel than their location and general appearance. Instead of the usual arrangement of placing the high-pressure cylinders outside the frames and the low-pressure between them, or *vice versa*, the two high-pressure cylinders are placed on one side and the two low-pressure on the other side of the engine, one of each being outside and the other between the frames. These two sets of cylinders are each cast in one piece together with their common steam chest, forming an exceedingly complicated casting. They are bolted together along the center line, the low-pressure cylinders being upon the left-hand side. The arrangement of cranks on the two sides of the engine follows the usual practice in that they are set 180° from each other and 90° from those on the opposite side. This makes it possible to use a single distribution gear for each set, or two for the engine, in accordance with the usual practice. At the same time, it will be noted that with this arrangement, the actual starting will usually be done with either the high or low-pressure cylinders, while the others may be exerting no turning moment at all. For example, if both high-pressure cranks are on the centers, the starting must be done by the live steam admitted to the low-pressure cylinders, the whole work being done upon one side of the engine. The moment the engine has passed the center, however, the other set comes into action. This is merely an extension of the conditions that exist with the two-cylinder compound to the working of the four-cylinder, and is unusual.

In order to clear the forward driving axle with the cross-heads and guides of the inside cylinders, the latter are raised and inclined downward toward the wheels. It is thus brought about that one high and one low-pressure cylinder are horizontal while the other two are inclined.

The four connecting rods drive the same axle, which is the middle one. This crank axle, the general appearance of which is shown by the engraving, is of nickel steel made by Krupp, and contains between 5 and 6 per cent of nickel. It is forged solid with the crankpins bored hollow with a 2 $^3/_4$ inches hole that extends back to the bend for the diagonal connection. This part is rectangular, with a thickness of 7 $^7/_8$ inches and a depth of 10 $^1/_4$ inches. The disc, uniting the crankpin portion to the journal, is strengthened by having a heavy steel band shrunk upon the outside. The valve gear is of the Walschaerts type and is driven from the outside crankpins and crossheads. The reversing mechanism will seem rather complicated to an American and can best be understood by following out the lines of connection on the engraving. This shows that the reversing lever is replaced by the vertical screw and shaft with a horizontal wheel, operating a block sliding in the jaws of a bell crank, from the vertical arm of which a connection leads forward to an intermediate lever suspended beneath the boiler, by which the motion is somewhat reduced, and is thence carried by another connection on to the arm of the lifting shaft. The radius bar and its hanger are counterbalanced by a weight. The valve is of the piston type and works in a steam chest that is above and parallel to the outside cylinder. The valve itself can be made simpler than that commonly used with four-cylinder compounds, in that it does not have to provide for the distribution of the high-pressure exhaust to the low-pressure cylinder and the final exhaust from the latter; for it has only to admit steam to the set of cylinders to which it is attached and exhaust the same when it has done its work. The ports leading to the two cylinders may have the same opening into the steam chest but cross in the casting, which makes it a complicated one to make, as already stated, but simplifies the valve construction and operation proportionately.

Steam is taken into the dry-pipe at the dome through a Zara throttle valve which has already been described in the *Railroad Gazette* of December 21, 1906. This is a balanced throttle, in which the use of a double seated valve is avoided, and the balance obtained by a piston at the lower end. In this case, it possesses a further modification by which steam is admitted to the receiver between the two sets of cylinders, whence it flows to the low-pressure steam chest and serves to start the engine. As the valve starts to open, a small valve at the side, controlled by a separate arm on the throttle rod, is opened and admits steam to the receiver. After the engine is under way, and the throttle is opened more, this passage port to the receiver is closed by the further movement of its valve and the engine is put into compound action. The general appearance is shown by the photograph of the apparatus as set up for demonstration. The dry pipe runs to the front tubesheet and then, at the T head, turns to the left, and drops down through the smokebox to connect beneath it with the flange of the high-pressure steam chest at the point shown on the plan.

The steam after having done its work is exhausted into a pipe 9 $^7/_8$ inches in diameter, that occupies the same position and reminds one very much of the pipe leading from the low-pressure cylinder back to the smoke-box in the Mallet compound built for the Great Northern Railway, and illustrated in the *Railroad Gazette* of October 12, 1906 (¹). In each case, an expansion joint has to be inserted. The single exhaust pipe of this engine finally terminates in a variable nozzle of the annular type that can be operated from the cab by the rod that is shown extending along the side of the boiler in the reproduction of the photograph; while the details of the mechanism can be followed out in the drawing. It consists simply of an arrangement of bell cranks and connections by which the two halves of the nozzle are turned backwards and forwards on hinges by which the opening about the central pipe is made larger or smaller. This central pipe is suspended from above and ends in a cone at the bottom by which a core is cut out of the center of the exhaust jet. The central cone is no novelty, but the use of a pipe reaching to the top of the stack by which the steam is prevented from filling the hollow that has been formed, will be new to most readers. The effect of this will undoubtedly be to give the exhaust jet a wider angle of divergence than it would otherwise have, while the presence of the pipe at the center will probably check the velocity of the blast, though this last effect will be hardly appreciable.

(¹) Vide also the *Bulletin of the Railway Congress*, No. 1, January, 1907, p. 121.

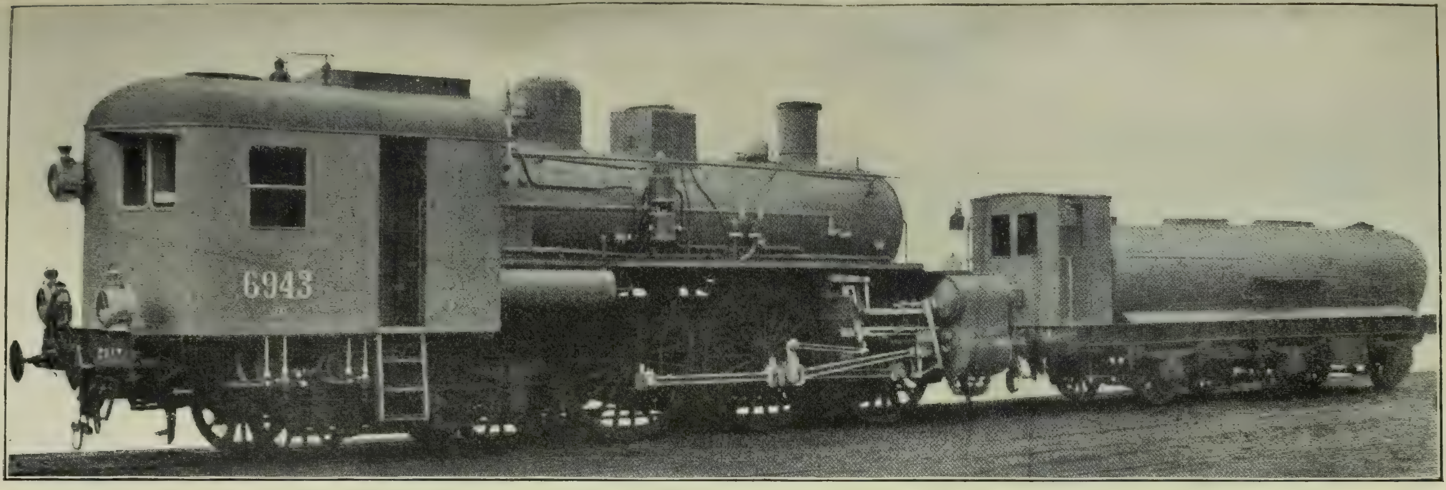


Fig. 9. — Four cylinder compound for Italian State Railroads. Normal position of engine and tender.

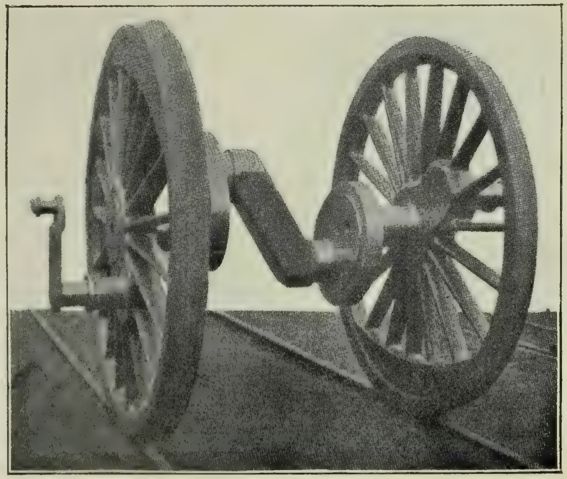


Fig. 10. — Crank axle, Italian locomotives.

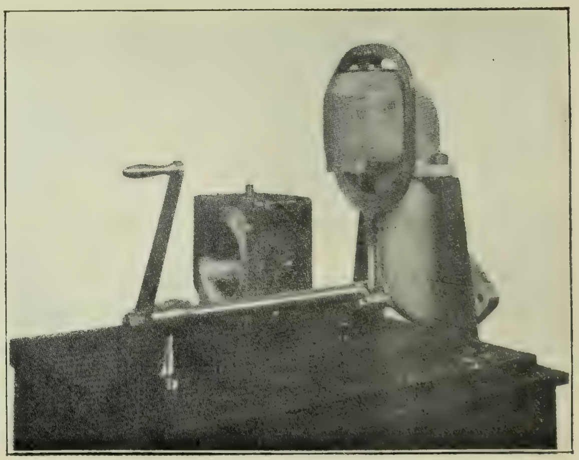
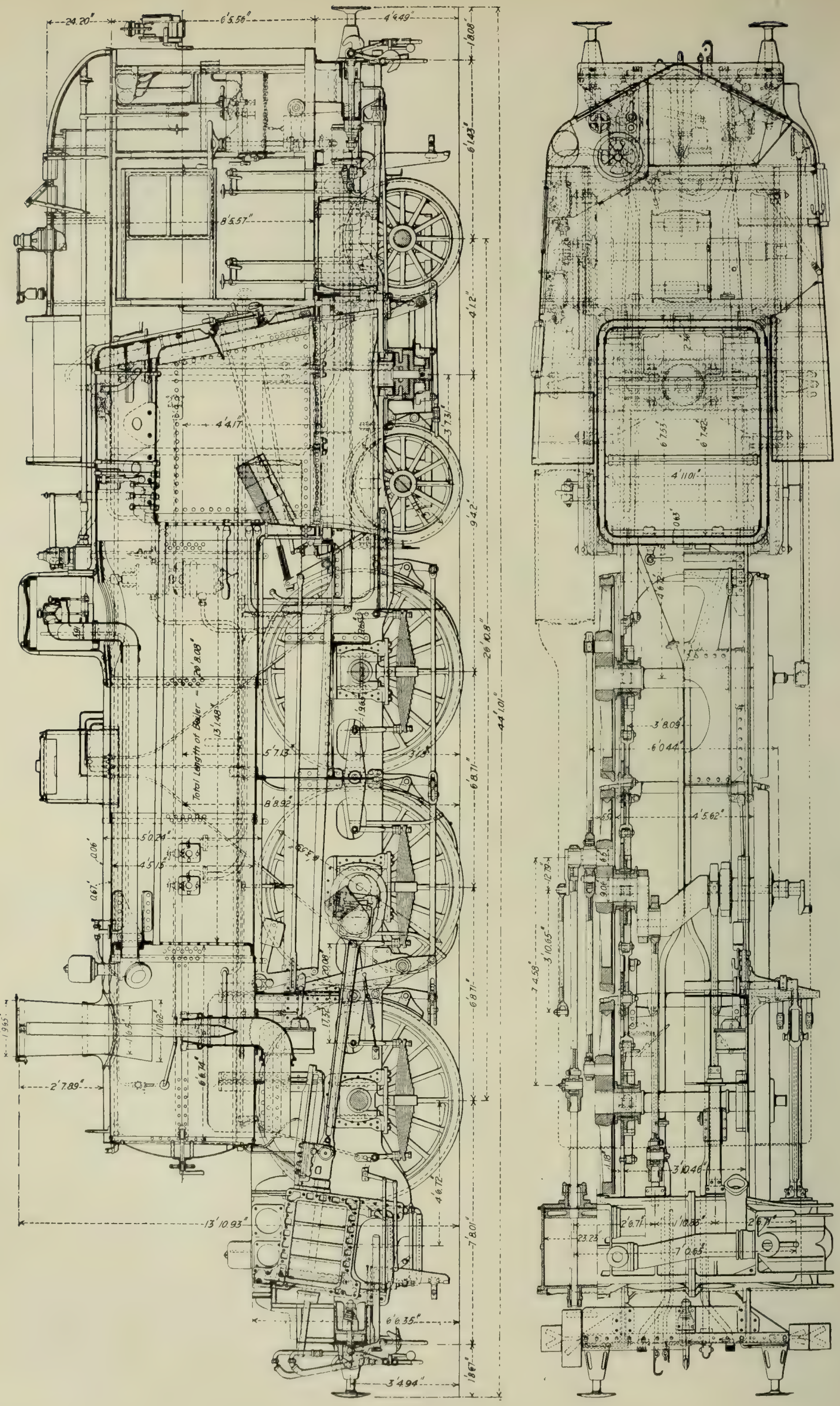


Fig. 11. — Zara throttle valve, Italian locomotives.



Figs. 12 and 13. — Plan and elevation of Italian four-cylinder compound.

The stack offers no particular novelty other than the damper over the top, which is common in European practice.

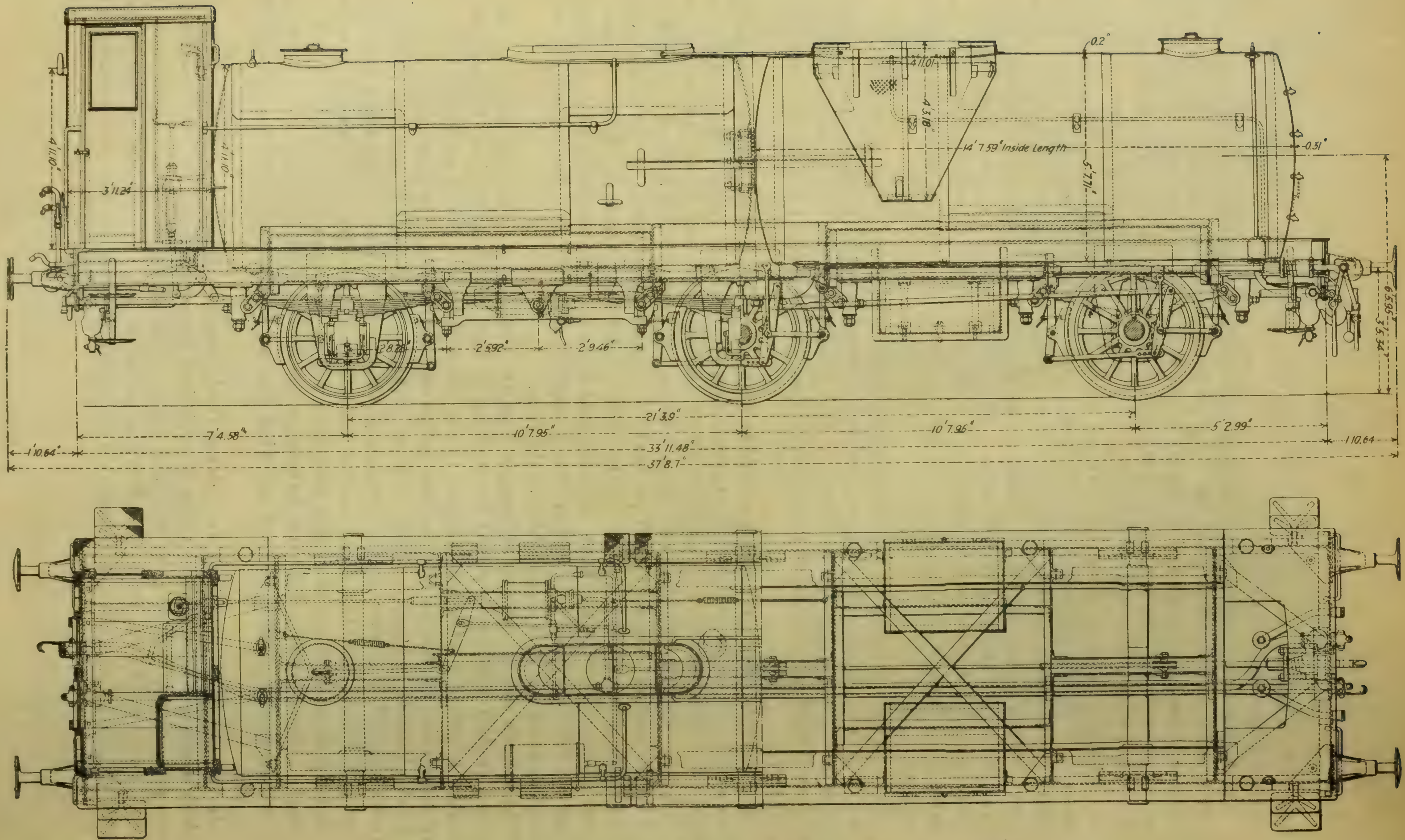
The spring suspension varies somewhat from American practice in the details of its arrangement. In the first place, the three pairs of drivers are equalized, but the equalizing bars are so proportioned that only about 30 per cent of the total weight on the drivers is carried by the main pair, while about 35 per cent is carried by the front and back pair, each. This just reverses the usual custom in the United States; where, if any difference is made, the greater weight is put on the main pair of drivers. Nor is this all. The driving springs are underhung and have a camber away from the load. That is, the main plate is bent back and down so that it has passed the horizontal position. This is something that is almost never done, and every attempt is usually made to avoid this condition of spring action. Finally, the spring hangers are acting under compression, and these are comparatively small bars or bolts of about 1 $^3/_{16}$ inch diameter, with the whole thrust taken against the face of the nuts by which the length is adjusted.

The engine is fittted with the Westinghouse brake, with shoes on all wheels, worked by two cylinders, one on each side, and set well forward beneath the smoke-box. A hand-brake of the screw type is also added, so that the driver brakes can be set in that way if it be desired, a condition that has not yet been provided for in similar service in this country.

The boiler is fitted with a copper fire-box with side sheets held by stays of manganese bronze, the composition of which is 94 per cent copper, 1 per cent tin and 5 per cent manganese. This produces a metal of about 43,000 lb. tensile strength with an elongation of 30 per cent. The fire-box roof-sheet and boiler shell are of iron, having a tensile strength of 53,000 lb. and an elongation of 27 per cent. The tubes are of brass. A short brick arch carried on side brackets is used. At the door, plates are inserted to protect the sheets from the shovel. For an engine of this length the tubes seem short, though, is reality, they are not particularly so, as they have a length of 13 ft. 1 $^1/_2$ in. The water leg is very narrow, being put 2 $^3/_8$ inches thick at the rear.

In the cab, we find still more changes from the usual order. Like the American suburban engines that are intended for working in both directions without turning, this engine is provided with coal bunkers in the cab. These are placed on the right-hand side, on beside the firebox and the other at the end, as shown in the plan. The capacity of these bunkers is 5 tons. With such an arrangement, it will be natural to expect that there will be a heavy load upon the right-hand side bearings of the truck when the engine is loaded, and that, if a variation is made in the strength of the springs to carry the loads imposed on the two sides, the engine will be thrown over to the left when it is empty. This is exactly what did happen in the case of some locomotives built for an American road a number of years ago when the coal bunker was placed on one side of the cab.

In the matter of cab and engine fittings the locomotive abounds in novelties, some of which would appear to American eyes to be decided inconveniences. Take the location of the operating parts in the front left-hand corner of the cab as an example. The throttle lever is suspended from the roof and swings across the cab. At the back of this is the screw reversing wheel, and over behind it is the engineer's valve. It may be a mistake, but



Figs. 14 and 15. — Tender for Italian four-cylinder compound locomotive.

it seems difficult to imagine an arrangement that could be much unhandier and one in which speed of manipulation, in case of an emergency, would be much more hampered, to say nothing of the exceedingly cramped space that is apparently given to the engineman in which to do his work.

The tender is quite as novel in design as the locomotive itself, and it is difficult to account for some of the details on the ground of practical utility. In the first place, it has a cylindrical tank, in which there is no novelty, but why the tender should have been provided with two tanks, placed end to end and connected by pipes at the bottom is difficult to understand. These tanks are each 5 ft. 7·7 in. in diameter and 14 ft. 7·6 in. long, and have a total combined capacity of 4,445 gallons. At the top of each, there is an oblong water hole, below which is a well of perforated metal, so that the water entering the main body of these tanks is strained of its coarser impurities.

In addition to the two tanks, the tender is also fitted with a brake van in wich is the brake wheel by which the brakes may be applied. Shoes are set upon each side of each wheel by means of a hand-operated screw that must take some time in its manipulation. The shoes are inter-fulcrumbed, so that all are brought to a bearing at the same time. One of the features of the tender is the readiness with which it can be detached from one end of the engine and attached to the other, it being the intention to provide for running the locomotive with either end to the front, but with the tender always at the rear. The running gear also varies somewhat from the ordinary type found abroad, in that the two pairs of wheels next the brake van are equalized, but with the equalization so proportioned that the greater weight is carried by the wheels at the end. Other than this, the spring suspension is typical of European practice, having the usual semi-elliptic springs over the journal boxes. Here attention may be called to the difference in the practice as shown on the engine and on the tender. On the latter, the spring hangers are in tension and the set of the springs is against the load, while on the engine, the reverse is the case, as already noted. The underframe is metal, with I-beam side sills, and the bracing follows the general lines of ordinary design.

In this engine, we have another instance of radical departures from accepted practice, as so often occurs on European railroads, where the mechanical superintendent has a free hand to build what he chooses, and where it sometimes seems that he was bent on doing something different from his neighbour. That such an engine will work all right, there can be no doubt, but when looked at with an eye to accessibility of parts and convenience of handling, it seems as though it left much to be desired. It is rarely that en engine appears that shows so much of originality of design and variation from current practice as this one. In fact, there is scarcely a point between the rail and the top of the stack that does not present some point of difference as compared with American practice, in addition to the points that have been touched upon. Such, for example, as the design of the truck, the shape of the cab, the rectangular sandbox, the safety valve on the dry pipe, the frames, the comparatively small diameter of the boiler shell, the high pressure, and, in fact, every detail entering into its construction, all of which makes it exceedingly interesting as a study of what is going on away from home.

The principal dimensions of the engine are as follows :

Cylinders, diameter, H. P.	14·17 inches.
— — L. P.	23·22 —

Piston, stroke	23·63 inches.
Wheels, diameter, driving	75·59 —
— — truck and tender	43·11 —
Wheel base of engine	26 ft. 11 in.
— — and tender	65 ft. 7·6 in.
Boiler, length	26 ft. 8 in.
— diameter of shell	4 ft. 5 in.
— thickness of shell	0·66 inch.
Fire-box, thickness of tube sheet	1·18 —
Heating surface	2,217·00 square feet.
Grate area	32·29 —
Tubes, kind	Serve.
— number	129.
— diameter	$2\frac{3}{8}$ inches.
— length	13 ft. $1\frac{1}{2}$ in.
Steam pressure	220 lb.
Height of center of boiler above rail	8 ft. $8\frac{7}{8}$ in
— of top of stack above rail	13 ft. 11 in.
Frame, total length of engine	40 ft. 7 in.
Engine, — over buffers	44 ft. 1 in.
— and tender, total length over buffers	81 ft. 9.7 in.
Weight in working order	155,680 lb.
-- on driving wheels	95,400 lb.
— of engine and tender	237,450 lb.
Coal capacity	5 tons.
Water capacity	4,445 gallons.
Working speed	56 miles per hour.
Tractive power	19,640 lb.
Ratio of high to low pressure cylinders	1 to 2·68.
$\frac{\text{Weight on drivers}}{\text{Tractive power}}$	4·85
$\frac{\text{Total weight}}{\text{Tractive power}}$	7·93
$\frac{\text{Tractive power} \times \text{diameter drivers}}{\text{Heating surface}}$	669·63
Fire-box heating surface	115·66 square feet.
$\frac{\text{Heating surface}}{\text{Grate area}}$	68·66
$\frac{\text{Fire-box heating surface}}{\text{Total heating surface}}$	0·052
$\frac{\text{Weight on drivers}}{\text{Total heating surface}}$	43·03
$\frac{\text{Total weight}}{\text{Total heating surface}}$	70·22
Vol. 2 H. P. cylinders	4·30 cubic feet.
$\frac{\text{Total heating surface}}{\text{Vol. 2 H. P. cylinders}}$	515·58
$\frac{\text{Grate area}}{\text{Vol. 2 H. P. cylinders}}$	7·5

[621 .132.5]

9. — Compound locomotive, St. Gothard railway.

Fig. 16, p. 957.

(*The Engineer.*)

The engine illustrated in figure 16 is one of a number just built for the most difficult services of the St. Gothard line — Gotthardbahn — where the maximum gradient is 1 in 38 and the curves and tunnels very numerous. The interesting feature of the innovation represented in the new engine, is the adoption in Switzerland of the Central-European system of the balanced compound locomotive. The engine is also the largest and most powerful of rigid frame locomotives in Switzerland.

This engine type, it will be observed, is constructed with all four cylinders in the same transverse line, all cylinders driving on a single pair of wheels — an arrangement which has proved adequate for the most powerful engines yet built in Europe — and with only one set of valve gears, the inside or high-pressure valves being actuated by rockers pinned to the top ends of the outside lead levers. The engine works compound always, so there is no intercepting valve. There are, as in all compound locomotives, automatically operated valves which admit live steam direct to the receiver in starting a train. These are visible at right angles to the low-pressure valve chests. They are of cylindrical pattern, one at each end of each low-pressure valve chest casings, and so connected by a light rod and arm to the reversing shaft or weigh-bar shaft that this latter — when the valves are given a cut-off exceeding 75 per cent of the stroke — opens the live steam valves. As in all very powerful engines, the low-pressure cylinders are of necessity placed outside of the frames. The radius rod in the valve motion is pinned to the lead lever in the position usual for slide valves, and this, together with the very long piston valve chests, shows that the valves have double heads for giving internal admission to the low-pressure cylinders. Anti-compression or relief valves are applied to all cylinder covers, and aspiration valves to the receiver. The whole of the mechanism, as well as the framework of the engine, is subject to very heavy stresses in working on the long, steep, and crooked inclines of the Alps traversed by the Gothard line, and it is instructive to note here the proportions in an engine built for the heaviest and most fatiguing of railway services.

The frames are of the bar type, in order to allow so powerful an engine to be provided with a very large boiler without exceeding the usual axle loads permissible — 15·5 tons. These low frames facilitated the design of the fire-box and ashpan. The front ends for the pilot wheels and buffers are of flat section, and the intermediate boiler supports are of thin plates, allowing of expansion movements by bending. These latter support the running boards, from the middle of which all four cylinders are simultaneously visible. The frame front ends are stayed to the boiler with round struts to resist lifting stresses.

The cab is of a pattern new to Swiss lines, of great size, but notable for the minimum amount of closed surfaces above the waist-rail susceptible of interfering with the all-round look-out of the enginemen. It is provided with aspiration roof ventilators of the Austrian type. On its sides, are glazed wing screens for protecting the eyes from sparks, etc., and to warn the men of the danger of obtruding the head from the side of a cab that fills the constructive gauge. The appendage below the cab is the Klose tachograph, which derives its movement, for the measurement of the angular velocity, from a roller in constant contact with the tire of the rear coupled wheel. The small mushroom-shaped whistle gives a deep, melodious note, which can be heard a great distance away.

The engineers of the Gothard line have been watching the results obtained from superheating for four or five years past, and its adoption for these locomotives appears to indicate a favourable opinion as to its sum-total advantage.

Eight of these fine engines have been built to the designs and at the works of J. A. Maffei, of Munich, Bavaria, and have just commenced regular work on the mountain division of the Gotthardbahn.

GENERAL DIMENSIONS.

High-pressure cylinders, diameter	$15^1/_2$ inches.
Low-pressure — —	$23^7/_8$ —
Piston stroke, length	24 —
Wheels :	
Driving	53 inches.
Pilot	$34^1/_4$ —
Boiler pressure	220 lb.
Heating surface :	
Fire-box	141·5 square feet.
Tubes	2,152 — —
Superheater	441·1 — —
Total (fire contact)	2,734·6 — —
Tubes : number, including stay-tubes	367.
Grate area	43·8 square feet.
Wheel base :	
Rigid	4,800 mill. (15·75 feet).
Total	7,520 — (24·75 feet).
Length of engine over all	11,032 — (36·2 feet).
Height of engine from rail	14 ft. 9 in.
Width over all	9 ft. 10 in.
Weight :	
Empty	70·7 metric tons (69.6 English tons).
Fully loaded	76·4 — — (75·2 — —).
— — for adhesion	62·2 — — (61·2 — —).

[656 .211.5]

10. — Electric baggage trucks.

Fig. 17, p. 958.

(*Railroad Gazette.*)

The Pennsylvania Railroad has recently built three electrically propelled trucks for carrying baggage and mail between trains, and the baggage and mail rooms in stations. Two are in service in the Broad street station, Philadelphia, and the third at Altoona. Although similar in general appearance, the three trucks differ in many essential details. They are still in the experimental state, and careful records are being kept to determine

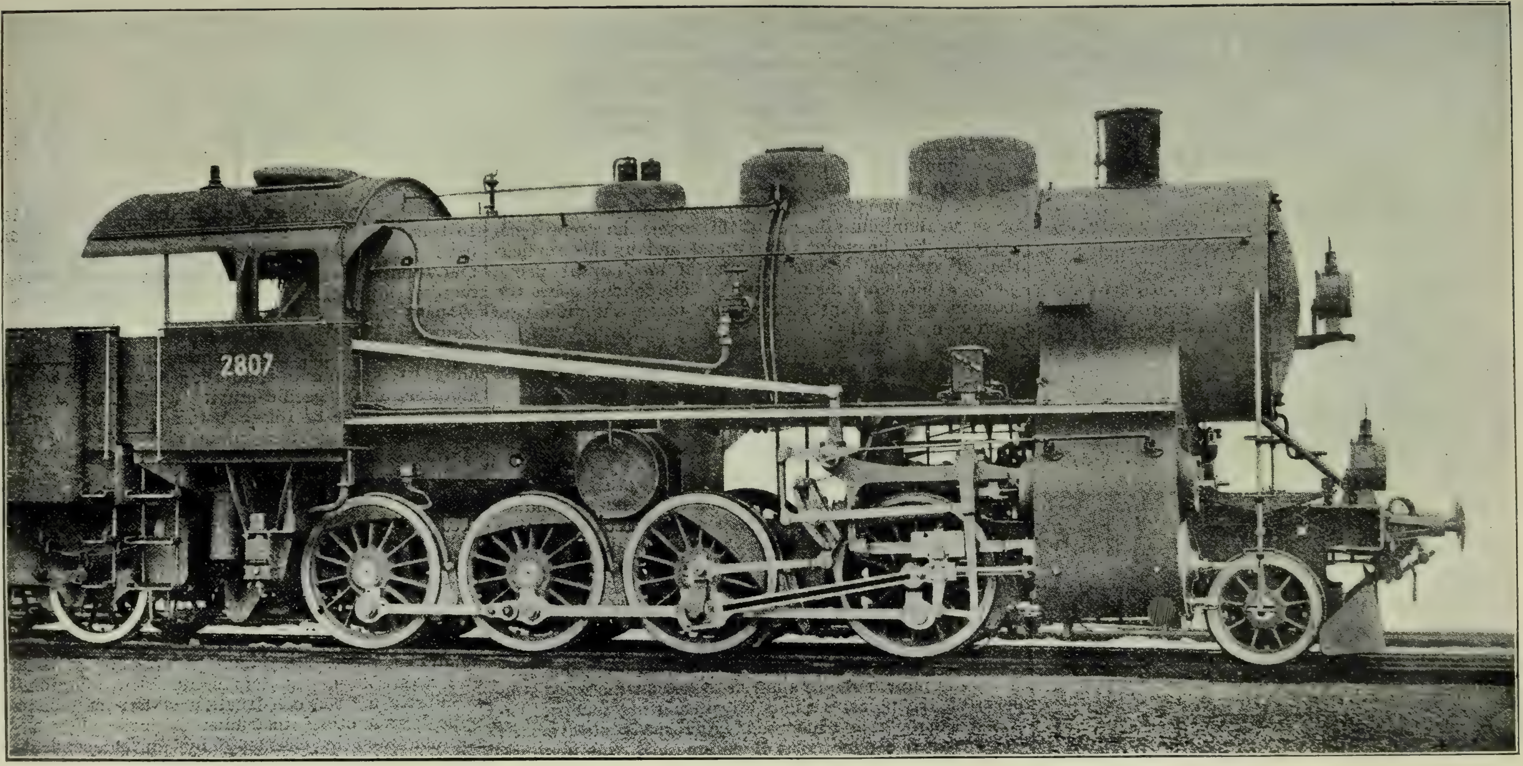


Fig. 16. — Compound locomotive, St. Gothard Railway.

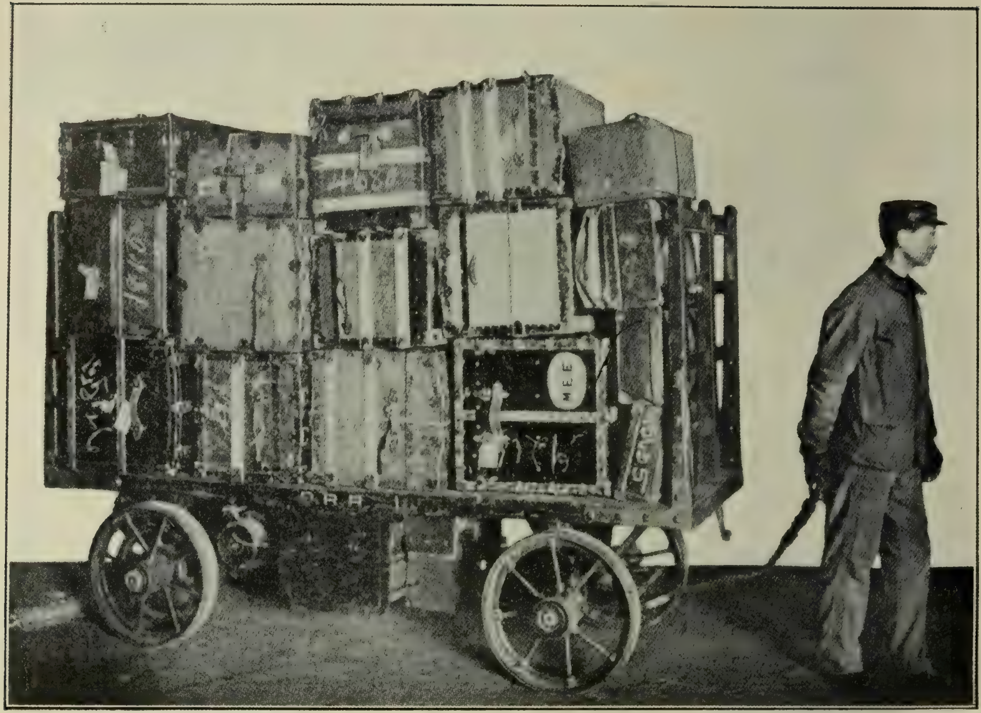


Fig. 17. — Electric baggage truck; Pennsylvania Railroad.

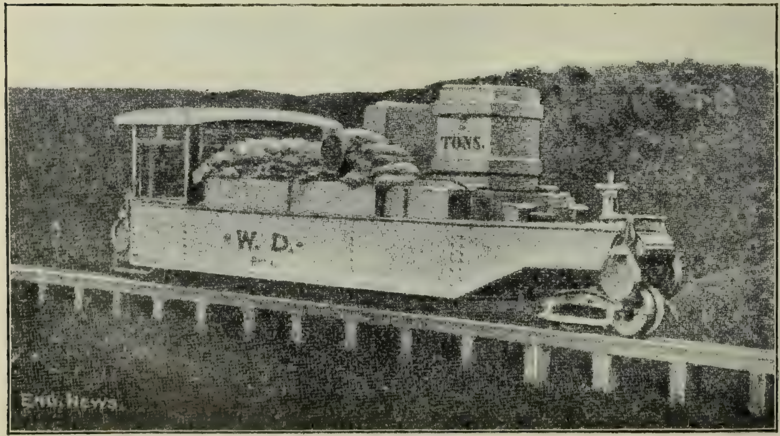


Fig. 18. — The gyroscope mono-rail car.

which type is the best for general use. The type of truck which has been found to be most serviceable up to the present time, is similar to the hand drawn type in common use. It is operated by one man, who walks ahead of it and steers the front wheels with a tongue or handle. Power is taken from a storage battery carried in a box secured to the under side of the platform. It consists of 14 Willard cells and has a capacity of 136 ampere hours. The batteries are charged about eight hours daily at the rate of 17 amperes.

Each of the rear wheels is driven by a Westinghouse type AA, 4-pole, series wound, 20-volt motor. Double reduction gearing is used between the motor and rear wheel, and each motor is provided with a solenoid brake of the multiple disc type on the end of its shaft. These brakes are essential for safe operation, for the truck cannot start itself even on an incline, and if in motion it stops promptly and automatically as soon as the power is shut off. Only two speeds forwards and two backwards are provided. These are approximately 4 and 6 miles per hour for the loaded truck, and on the crowded platforms they have been found fast enough.

The two motors are operated in series, and on the low speed a wire resistance is inserted. The motor current is controlled by two single pole solenoid switches, one for the low and the other for the high speed. The solenoid switches are enclosed in a box in front of the storage batteries, and the current for operating them is controlled by contacts in a small box on the outer end of the tongue or handle. The contact box is of metal, cylindrical in form, and operated by a rod which slides axially through it. The rod is provided at one end with a ring, which is grasped by the operator. A slight movement of the rod starts the truck forward at low speed; a further movement of the rod gives the high speed. The rod is returned to the of position by a spring, so that when the ring is released the truck stops. It cannot be started by any accidental knock, but only by an intentional pull on the ring. The pole changing switch for running the truck backwards or forwards, is located in the box with the solenoid switches and operated by a small lever under the front of the platform. The tongue or handle is connected by reach rods to pivoted bell cranks carrying the two front wheels in a way similar to that generally used upon automobiles. This truck has been in successful operation about six months. One man can handle heavy loads of baggage and mails quickly and easily.

[625 .5]

11. — The gyroscope mono-rail railway.

Fig. 18, p. 958.

(*Engineering News.*)

Cable dispatches from England on May 8th reported the exhibition before the Royal Society on that date of the model of a most remarkable new form of mono-rail railway, invented by Louis Brennan, C. E., the inventor of the Brennan torpedo. All previous inventors of single-rail transportation systems have either used an elevated rail and suspended car (as in the telpherage system and the Barmen-Elberfeld railway), or they have used auxiliary whells and rails overhead, or at the sides, to steady the car on the single rail and prevent it from tipping over.

Mr. Brennan appears from the accounts to have invented a car which can balance itself on a single rail like a tight-rope walker, or rather with much more security than a tight-rope walker, since it does not tip over — according to reports — even if its weight is not balanced over the central rail.

The first cabled accounts of the invention were too meager for one to form any idea concerning the invention; and we have, therefore, awaited the arrival of the English journals, *Engineering* and *The Engineer*, for more circumstantial statements of what Mr. Brennan has actually accomplished. The numbers of these journals containing the report of the Royal Society soiree have now come to hand, but we are still left as much in the dark as ever as to the exact mechanism by which Mr. Brennan accomplishes his paradoxical feat in mechanics.

We print, however, in full below the description of the invention in *The Engineer*, with the illustration accompanying it (fig. 18). It will be noticed that *The Engineer's* account is based on examination of a working model on Mr. Brennan's estate; its representative, however, is exceedingly hazy in his statement as to the method by which the gyroscopic apparatus actually operates to maintain the stability of the car :

" At the invitation of Mr. Louis Brennan, C. E., we recently visited his house at Gillingham to witness some trials of a new type of mono-railway, on the design of which he has been engaged for some years. This railway has been built only on a small scale, the model being one-eighth of the size of a similar railway which the inventor is at present constructing. Briefly stated, the model mono-railway may be said to consist of a circular section rail laid on wooden sleepers on the ground, or it may be laid on piles, as would be required on the slope of a steep hill, such as shown in the illustration. In places, the track consists only of a stout steel rope tightly stretched to represent the construction of a bridge across a ravine. The car somewhat resembles in shape a large pontoon or barge. Part of the inside is arranged for passenger accommodation, and part for goods. The car is carried on two bogies, one at each end. These bogies are so pivoted that they allowed the car to turn easily on curves, and also vertical movement. By this means, it is claimed that the vehicle can run upon curves of even less radius than the length of the vehicle itself, or on crooked rails, or on rails laid on uneven ground, without any fear of derailment.

" The inventor, as is natural, is very sanguine as to the future of his railway; to use his own words :

" By its means vehicles of colossal dimensions, more like moving hotels or ships on " shore than the usual form of railway carriage, will travel at velocities of probably " from two to three times that attainable at present; at the same time, there will be a " complete absence of lateral oscillation in the carriages, and a great increase in the " smoothness with which the will run***. Every facility can be given for the enjoyment " of life while traveling, as the carriage may be fitted up with all the comforts of a first-" class hotel, and separate rooms provided for every purpose, such as smoking, dining, " reading, writing, etc., even promenade and music rooms, will probably be provided to " relieve the tedium of railway traveling."

" Whatever we may think for or against this system for railway work in general, we cannot but admire the manner in which the inventor has applied gyrostatic principles to it.

"Returning for a moment to the construction of the car. We have already stated that is is carried on four wheels. Each pair of these wheels is coupled, and one in each set is driven direct through gearing from electric motors carried on the bogies. The power for propulsion is derived from a number of small secondary cells placed inside the car, but by far the most interesting part of the carriage, is the means adopted for maintaining equilibrium, for it must be at once apparent that the center of gravity of the car is much higher than the center of buoyancy, and consequently it is an unstable body. To overcome this, Mr. Brennan has introduced two gyroscopes mounted on bearings which run in a partial vacuum. These gyroscopes work in a vertical plane and run in opposite directions; the are connected together by suitable gearing, so that their peripheral velocities are equal. This arrangement overcomes the difficulty which would be experienced in turning, were they not so constructed. Special means are provided for advancing the precession of the gyroscopes, and thereby causing them more quickly to return to the horizontal plane. It was very interesting to notice how the car, when going round a curve, leaned inwards, returning to the vertical position directly it passed on to the straight rail again. It was also interesting to notice how when a heavy weight was thrown on to the side of the car the latter rose, instead of dipping, as one would at first expect it to do. The explanation of this is simple, a recognized phenomenon of the gyroscope, and need not be entered into here. The gyroscopes were motor-driven, and ran at a speed of from 7,000 to 8,000 revolutions. This mechanism occupies little space, and it was stated that, in larger cars, it will only be about 5 per cent the total weight of the vehicle.

"The model was built essentially to illustrate the value of the invention for military use, and was, therefore, designed with a low speed — about seven miles per hour — but with good hill-climbing capabilities. The trials, which lasted for some time, were successfully carried through. The car was loaded with weights representing 20 tons, and, in order to prove its stability, a weight corresponding to that of fifteen men was thrown suddenly on to the side of the car, and as we have already stated, the side of the car on which the weight was gradually thrown, rose to restore the position of equilibrium. To show how well the car could turn, an ordinary steel rope, about $^5/_8$-inch in diameter, was laid on the lawn, and round the many turns specially arranged for the purpose, the little car wended its way very gracefully. It appeared to experience no difficulty in climbing gradients of 1 in 5, and on one occasion the bank was said to be 1 in 2 $^1/_2$; however, this was shot, and the car had a "rush" at it. But, loaded as it was, the climb up 1 in 5 was an excellent performance for so small a car. At the conclusion of the trials one gentleman, weighing nearly 140 lb., was given a ride round the miniature track, and he finally crossed the wire bridge, which had a somewhat considerable span. That so small a car could take the weight it did and run so well shows that, whatever be the future of this type of monorail, there can be no question as to its success on the small line we had the pleasure of inspecting.

"Mr. Brennan is at present engaged upon the construction of a full-sized vehicle, 12 feet in length, similar, we believe, to the model just described. It will, however, be driven by a petrol engine of 100 horse-power direct coupled to a motor. The gyroscopes will be 2 ft. 9 in. diameter, and will have a speed of from 2,000 of 3,000 revolutions per minute. The road wheels will be power driven, and change gears provided to facilitate hill climbing. It will also be possible to free-wheel down hill. Brakes capable of being operated by pneumatic or manual power will be fitted to all the wheels. The inventor considers that one of the most valuable applications of his mono-rail will consist in its adaptation to vehicles of ordinary dimensions, which will serve as feeder lines to existing railways, and pioneer lines in new countries, such as the colonies. By this means, he states, it will be possible to construct lines at a minimum cost, and give settlers a means of getting their produce to market with great speed and economy.

"Our illustration shows the railway constructed on the side of a hill — a construction which Mr. Brennan states is frequently required in India, where notching in the side of a hill would cause many tons of material to fall from higher up the hill-side. It is also claimed that this construction in no way interferes with the natural drainage of the land."

The account in London *Engineering* refers only to the exhibition of the invention before the Royal Society, and gives no additional information to that contained in the above. A little additional, though not very much, is contained in a cable dispatch to the New York *Sun*, which quotes the inventor's own claims for his invention as follows :

"The characteristic feature of this system of transport is that each vehicle is capable of maintaining its balance upon an ordinary rail laid upon sleepers on the ground, whether it is standing still or moving in either direction at any rate of speed, notwithstanding that the center of gravity is several feet above the rail and that wind pressure, shifting of load, centrifugal action or any combination of these forces may tend to upset it.

"Automatic stability mechanism of extreme simplicity carried by the vehicle itself endows it with the power. The mechanism consists essentially of two flywheels rotated directly by electric motors in opposite directions at a very high velocity, and mounted so that their gyrostatic action and stored up energy can be utilized. These fly-wheels are mounted on high class bearings and are placed in exhausted cases, so that both air and journal friction is reduced to a minimum, and consequently the power required to keep them in rapid motion is very small.

"The stored up energy in the flywheels, when revolving at full speed, is so great and the friction so small, that if the driving current is cut off altogether, they will run at sufficient velocity to impart stability to the vehicle for several hours, while it will take from two to three days before they come to rest. The stability mechanism occupies but little space and is conveniently placed in the cab at one end of the vehicle. Its weight is also small, about 5 per cent of the total load being considered an ample allowance for the first vehicle.

"Everything points to great economy resulting from making the vehicles wider in proportion to their length than on ordinary railways, and it has, therefore, been decided to make the experimental wagon 12 feet wide, or one and a half times as wide as usual. For civil work in the colonies, the vehicles will probably be two or three times as wide, if not more.

"Bridges are of the simplest possible construction, a single wire hawser stretched across a ravine or river being all that is necessary for temporary work. These hawsers can be built up on the spot from separate wire rope strands, so that the transportation of them becomes an easy matter. Strange to say, the lateral swaying of the hawser does not disturb the balance of the vehicles, and the strongest winds will fail to blow them off."

It will be noted that the exact arrangement of the gyroscopes which perform the wonderful feat of keeping the car balanced over its point of support, is not disclosed in any of the above accounts. It may interest some of our readers who are mathematically inclined and familiar with the gyroscope, to puzzle out how a pair of rotating fly-wheels can be made to prevent an unstable body from tipping over in obedience to the law of gravitation. That this seemingly impossible feat has been actually accomplished (with a small model) appears certain, if we may trust our esteemed British contemporaries. That the feat is a scientific marvel of the first magnitude will certainly be agreed by all.

Turning now to the projects for the practical application of the invention, we confess ourselves unable to see any prospect of the use of such a system of transport as a competitor of the ordinary two-rail railway. Granting all the claims of the inventor, it appears impossible that any such system could be seriously considered for a high speed line, since it would be inherently more dangerous than the ordinary two-rail system. The proposition of the inventor to operate cars of extraordinary widths on this system, may also be set down as an absurdity.

The chief practical field for the invention, if the claims for it are substantiated on further investigation, would appear to be for the construction of very light, cheap lines for handling traffic of small volume. Some form of transportation line which can be built and maintained at a small cost is needed in a thousand places, as feeders to existing railways, as mining and lumber railways, as pioneer lines, for military work, for contractors' use, and on ranches and plantations. If the mechanical complication and expense of Mr. Brennan's invention is not too great, it may be of extensive application in this field.

[656 .253]

12. — Illuminating semaphore signals.

Figs. 19 to 21, pp. 964 and 965.

(*The Railway Gazette.*)

Great is the importance to railway companies of securing maximum efficiency where the apparatus employed for signalling trains is concerned. Improvements in this branch of railway equipment directly influence the factor of safety in controlling traffic, which factor is raised in accordance with the degree of practical utility which the improvement in method or device shows itself, in working, to possess.

The modern tendency to increase the speed of trains, not only on main lines but also those running on short-distance and suburban services, has rendered accuracy in the signalling operations still more imperative, and with the advent of electric traction on railways, the subject takes a wider scope, and therefore presents an increasingly important and more intricate problem than heretofore. Many ingenious devices have been patented during recent years for improving railway signalling apparatus. Some have been adopted and others would doubtless have secured the same reward but for the fact that the improved results to be obtained from them would only be reached at the expense of more complicated mechanism, which generally means that greater attention and skill is demanded from the signalmen, and as this renders more prominent the always doubtful human element, many otherwise valuable inventions have had to be rejected. Among recent patents relating to signalling apparatus on railways and one which, because of its obvious merit in combining improved results with simplicity of working methods, is that of Mr. J. A. Panton, A. M. I. E. E., of the Liverpool Overhead Railway.

This is an ingenious automatically illuminated and reversible semaphore arm for use on electric railways or where an electrical supply can be obtained. The object of the invention is to render signals more discernable by night or day, but more especially by night, thereby minimising the risk of accidents such as those which have so frequently occurred lately, owing to drivers passing signals when the latter are at "danger." An obvious deduction from such accidents is that a weakness exists between the present methods of signalling by visual means and the human element. The problem, therefore, is to render such visual signals more intelligible and perceptible to those whose duty it is to read them. In designing the improvements incorporated in his invention, Mr. Panton kept before him the conditions of simplicity, with certainty in giving decisive yet electrical results.

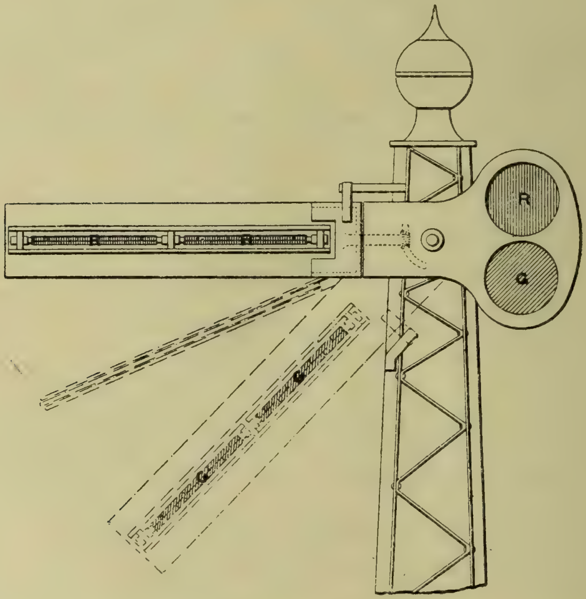


Fig. 19. — Semaphore arm, reversing and illuminating automatically.

R = Red ; G = Green.

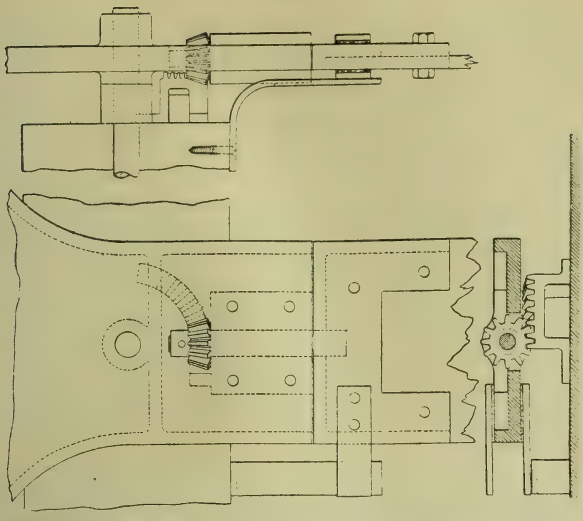


Fig. 20. — Details of reversing gear and electrical contacts.

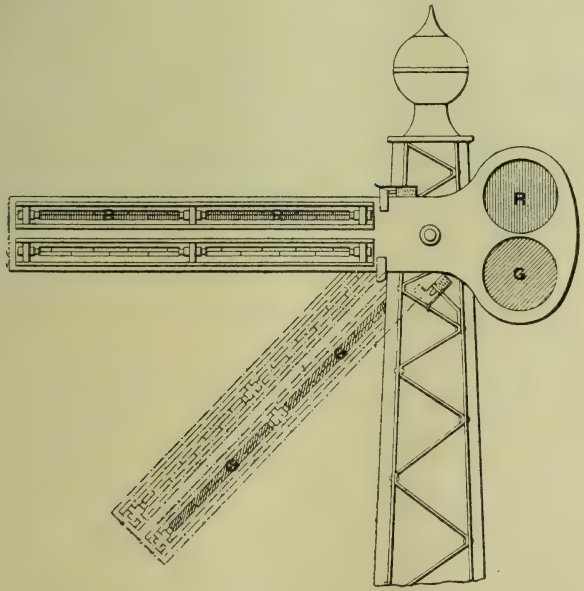


Fig. 21. — Ordinary signal arm, automatically illuminated.
R = Red; G = Green.

The improvements will be best understood by a study of the drawing. It may be briefly stated that the improvements consist in the semaphore arm carrying a line of light on its face or on both faces, in addition to the present coloured spectacles, and also in causing the semaphore arm to reverse its face in the act of raising or lowering the said line of light changing colour automatically, the red light being shown when the arm is raised and a green light when it is lowered, or different colours could be used to distinguish between " home " and " distant " signals. Similarly in daylight, with all lamps extinguished, the red face of the reversing arm is presented to the driver when the arm is raised, whilst its white or green face is presented when the arm is lowered, thus giving the driver a further means of identifying the signal, especially when entering terminal stations where so many signals are grouped together and liabilty to make mistakes occurs.

Referring to the drawing, it will be noticed that the spectacle casting is in two portions, one portion carrying the spectacles, whilst the other portion carries the wooden arm, and is revolvable on a trunnion, which is mounted in a bearing in the spectacle casting. Fixed on this trunnion is a pinion wheel which meshes with a rack on the post, consequently, as the arm is raised or lowered, this pinion causes the outer wooden portion of the arm to rotate and make half a turn. Two separate and insulated contact pieces appertaining to the lamps are positioned on the arm, so as to engage with two electrically-connected contacts on the post, whereby the lamps are lighted, only when the arm is in its correct raised or lowered position. It cannot be illuminated at any other angle.

Among the advantages which, it is claimed, attend the use of this invention may be mentioned : 1° the greatly increased conspicuousness of the visual signal ; 2° the change in the position of the coloured lights in addition to the change of colours ; 3° in daylight, the reversing arm presents its white or green face when lowered ; 4° saves life and also fog-signalling expenses. The warmth of the lamps and the fact of reversing will prevent the signal from becoming obscured by snow, etc. For simplicity and efficiency, this is superior to anything else at present in use, and has received the approval of the Board of Trade. Modifications of the invention permit, among other things, of the central portion of the arm, carrying the straight filament lamps, alone rotating instead of the entire arm doing so, or the lamps alone may rotate. The glass of the lamp may be coloured or it may be enclosed within a coloured semaphore without reversing, as shown here, wherein the face of the arm presented to the driver carries two straight filament lamps, one being coloured red, and the other green.

Each lamp has a separate contact piece on the arm, which contact pieces engage with terminals on the post as the arm is raised and lowered respectively.

The terminals on the post are arranged in conjunction with spring plungers, the function of the latter being to arrest the movements of the arm without jar.

Thus the red lamp is automatically illuminated when the arm reaches its raised position, and the green lamp is similarly illuminated when the arm reaches its lowered position, both lamps being extinguished when the arm is in action.

The distinction by colour as well as position is, therefore, a real advance in modern railway signalling.

[625 .216]

13. — Gould friction draft gear.

Figs. 22 and 23, pp. 967 and 968.

(*Railway and Engineering Review.*)

A friction draft gear which is meeting with increasing favor is that brought out by the Gould Coupler Company, New York City, some three years ago, so that there has been ample time for its merits to have been proved in extensive service. It will be remembered that this is the design shown in figure 22, accompanying, which consists simply of a malleable iron barrel containing frictional elements, which are merely two sets of plain wedges. These wedges are kept in position and thrown into frictional engagement by two sets of semi-elliptic steel plates, opposed as shown. The thrust upon these plates is provided by the cap of the coil spring which affords the yielding resistance.

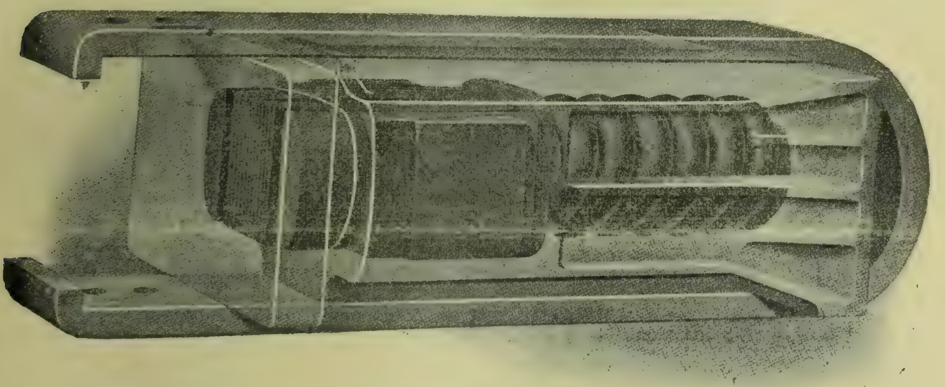
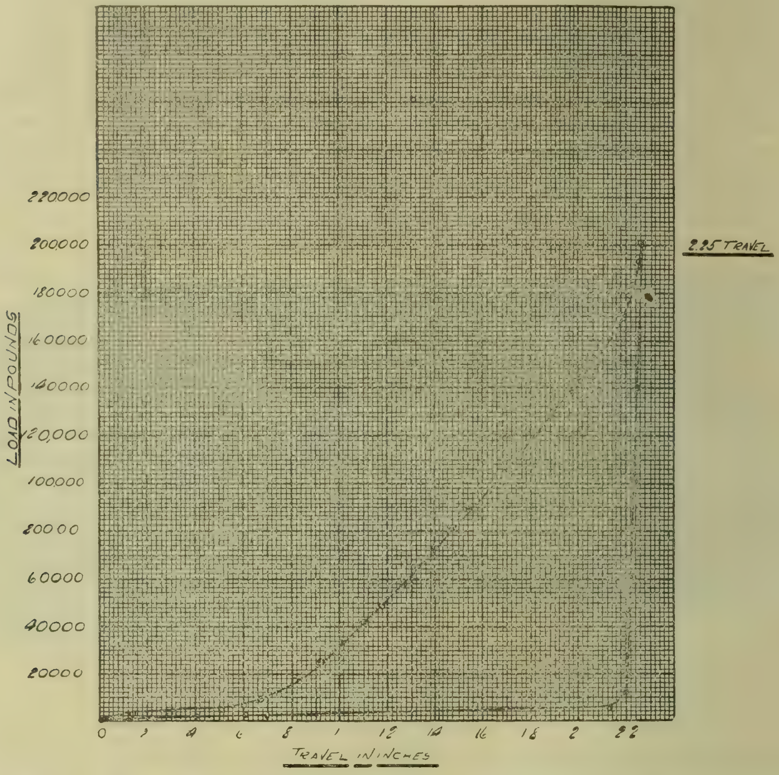


Fig. 22. — Gould friction draft gear.

The gear is exceedingly simple, as it consists of a small number of parts of plain and substantial design, and thus is easily assembled or taken apart. The friction faces of the wedges and wedge plates must be true and plane, but do not require fine machining. The leaf springs are all alike, thus avoiding any possibility of mistake in assembling. The friction parts have ample wearing surfaces. The wedges and wedge plates are drop steel forgings case hardened. The gear closes solid before the flat springs are compressed to the limit of their capacity, and therefore the springs are not liable to injury. There is no wear on the barrel. If the wedges wear and the gear becomes slack, a shim placed between the two sets of leaf springs will restore it to its full capacity.

It has a high capacity, and is designed to meet all the requirements of the most severe service. Tests made on the testing machine at Cornell University, figure 23, show that it affords a yielding resistance of 200,000 pounds, has a very small recoil action, and works smoothly without jerks or irregularities. Under a load of 300,000 pounds, the capacity of the testing machine, the gear developed no defects. In a series of drop tests with a

1,640-pound drop, the gear stood 77 blows as follows : One blow for each foot from 1 to 10 feet, 65 blows at 10 feet and 2 at 15 feet. It was still fit for service, and without any change of parts was placed under the testing machine at Cornell University and registered a capacity of 200,000 pounds with 2 inches travel. The width and shape of barrel which contains the gear, may be made to suit any requirements.



Fig, 23. — Compression test of Gould friction draft gear.

[625 .252]

14. — Armbrust brake shoe.

Figs. 24 and 25, p. 969.

(*Railway and Engineering Review.*)

The Love Brake Shoe Company with offices in the Fisher building, Chicago, put out on the market last August a new type of brake shoe — the Armbrust brake shoe for locomotives, tenders, passenger and freight cars. These brake shoes involve new principles, chief among which are the following : Scoring at the shoe's center causes any accidental breakage to occur at that immaterial point, spacing lugs cast on the back of the shoe to space the shoe-body away from the brake head, enabling it to wear entirely out without danger of it wearing into the head, even should the shoe wear unevenly, a steel connector cast in the spacing lugs on the back of the shoe (not in the body of the shoe, which would weaken it).

The latter feature is for purpose of holding broken parts, should accidental breakage occur at any points other than at the center, firmly in place until worn out, thereby obviating all danger of wrecks, etc., by broken shoes falling to the track. This construction increases the factor of safety to a maximum, which is an item for the serious consideration of railroad officials. The scoring of the shoe at the center, causing any breakage to occur at that immaterial point, permits the shoe to adjust itself to the tread of the wheel, thereby giving better service on the tires and adding to the life of the shoe. This also enables the shoe to fit the brake head at the four points of contact, taking the strain off the shoe and throwing it on to the brake head where it properly belongs.

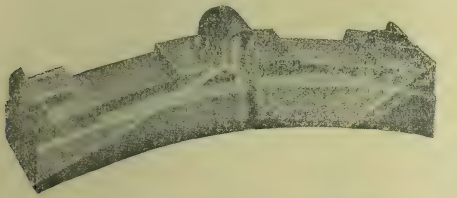


Fig. 24. — Armbrust car brake shoe.

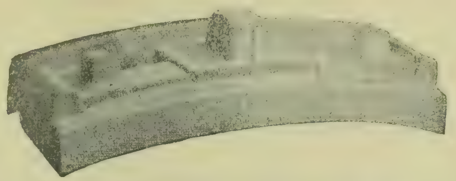


Fig. 25. — Armbrust driver brake shoe.

The body of the Armbrust shoe, either car or driver, can be worn entirely out, right down to the steel connector, and is as safe at the last quarter inch stage of wear as at the first; the scrap remaining amounts to about 3 lb. in the car shoe and about 10 lb. in the driver shoe. The Armbrust car shoe is especially well adapted for high speed trains with new increased air pressure. This shoe has also proved particularly attractive to elevated rolds, as no broken brake shoes can possibly fall to the street and cause injury and damage.

Aside from the above features in the driver shoe, it is pinned to the brake head the same as the car shoe, although where roads desire, it can be constructed so as to bolt and hook on the brake head. On account of the former construction, it is not necessary to have rights and lefts and, therefore, the road does not need to carry so much stock; also, as there are no rights and lefts the shoe, when worn more on one end than on the other, can be turned, the same as is the practice in car shoes. The Armbrust brake shoe is attracting the attention of the railroads all over the country and has been adopted as standard on several roads.

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[016 .385. (02]

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Leipzig, G. A. Gloeckner. In-8°, 64 Seiten.

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[1] The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly the Office Bibliographique International, of Brussels. (See "Bibliographical Decimal Classification as applied to Railway Science," by EISSENBRUCH, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

N. B. — The Monthly Bibliography is printed on one side only so that it may be cut up into slips and pasted on labels for catalogues and indexes.

1907 **351** .812

GLEIM (W.).

Das Gesetz über Kleinbahnen und Privatanschlussbahnen vom 28. Juli 1892.

Berlin, Franz Vahlen. 4. Auflage, in-8°, VIII + 451 Seiten. (Preis : 9 Mark.)

1907 **624** .8 (02

Handbuch der Ingenieurwissenschaften. II. Band. 4. Abteilung: **Bewegliche Brücken.** Bearb. von Professor W. DIETZ.

Leipzig, W. Engelmann. 3. Auflage, in-8°, XIV-315 Seiten mit 262 Textfiguren, Sachregister und 3 lithographirten Tafeln. (Preis : 10 Mark.)

1907 **624**. (02

Handbuch der Ingenieurwissenschaften. II. Band. 3. Abteilung : **Die Konstruktion der eisernen Balkenbrücken.** Die Brückenbahn. Bearb. von K. BERNHARD und Th. LANDSBERG.

Leipzig, W. Engelmann. 3. Auflage, in-8°, x-275 Seiten mit 276 Textfiguren, Sachregister und 16 lithographirten Tafeln. (Preis : 12 Mark.)

1907 **625** .13

METTLER (Dr. Alfons).

Der Splügen als ostschweizerische Alpenbahn. Verkehrspolitische Untersuchungen.

Zürich.

1907 **625** .13

MÖRING (Dr. Alwin), Professor der Kantonsschule St. Gallen.

Die Simplonbahn. Eine verkehrswirtschaftliche Studie.

Bern, Stämpfli & C^{ie}. 206 Seiten.

1907 **69** (02

SCHINDLER (Karl).

Eisenkonstruktionen im Hochbau. Kurzgefasstes Handbuch mit Beispielen für den praktischen Gebrauch.

Leipzig, G. J. Göschensche Verlagshandlung. In-8°, 127 Seiten mit 115 Abbildungen im Text. (Preis : 80 Pfennig.)

1907 **621** .134.3

SCHMIDT (Wilh.).

Die Anwendung von Heissdampf im Lokomotivbetriebe nach lem System von Wilh. Schmidt.

Cassel, E. Röttger. 40 Seiten mit Abbildungen und 5 Tafeln 320 × 245). (Preis : 2 Mark.)

In English.

907 **385**. (08 (.54) & **313** .385 (.54)

Administration Report on the Railways in India for the ilendar year 1906.

Simla, printed at the Government Central Printing Office. n-4°, 283 pages with a map. (Price : 2 rupees.)

1907 **621** .33 (02

AGNEW (W. A.).

The electric tramcar handbook for motormen, inspectors, and depot workers.

London, Alabaster. Fourth edition, 8vo, 130 pages. (Price : *2s. 6d.*)

1907 **624**. (01

DERLETH (Charles) Jr., C. E.

Design of a railway bridge pier.

New York, Engineering News Publishing Company ($10\,^1/_4 \times 6\,^3/_4$ inches), 24 pages. (Price : 50 cents.)

1907 **621** .1 (02

HECK (R. C. H.).

The steam-engine and other steam-motors : a text-book for engineering colleges and a treatise for engineers. V. 2 : Form, construction, and working of the engine : the steam turbine.

New York, D. Van Nostrand Co. 8vo, il., diagrams. (Price : $5.)

1907 **389**

McCARTNEY (Hugh P.).

Metric weights with English equivalents.

London, E. & F. N. Spon. ($4 \times 3\,^1/_4 \times {}^1/_4$ inches), 83 pages. (Price : 1*s.*)

1907 **697**

MAXWELL (W. H.).

Ventilation, heating and lighting.

London, Sanitary Publishing Co. Second edition, 8vo ($7\,^1/_2 \times 4\,^3/_4$ inches), 158 pages, illustrated. (Price : 3*s.*)

1907 **62**. (01

MERRIMAN (Mansfield).

The strength of materials : an elementary text-book for manual training schools

New York, John Wiley & Sons. 12mo, 156 pages, illustrated. (Price : $1.)

1907 **313 : 656** .28 (.42)

Railway accidents. Reports of inspectors on accidents and casualties reported to the Board of Trade during October to December 1906.

London, P. S. King & Son. Plans. (Price : 2*s.* 6*d.*)

1907 **625** .25 (02

RANDOLPH (Vern Curtis).

Air brake catechism and instruction book on the construction and operation of the Westinghouse and New York air brakes with a list of examination questions and answers for enginemen and trainmen.

Salamanca, N. Y., V. C. Randolph. 24mo, 101 + 3 pages, tables. (Price : $1.)

1907 **625** .618
SAYERS (H. M.).
Brakes for tramway cars.
London, Electrician. 8vo (8 3/4 × 5 1/4 inches), 82 pages. (Price : 3*s*. 6*d*.)

1907 **621** .133.7
SCHMIDT (Edward C.) & **SNODGRASS** (John M.).
Effect of scale on the transmission of heat through locomotive boiler tubes.
Urbana, Ill. The University. (9 × 6 inches), 24 pages, 10 ill. partly in the text.

1907 **385.** (02
SINCLAIR (Angus).
Railroad men's catechism.
New York City, 136, Liberty street. (6 × 4 inches), 200 pages. (Price : 1 $.)

1907 **621** .335
STILLWELL (Lewis B.) & **PUTNAM** (H. St. Clair).
Substitution of the electric locomotive for the steam locomotive. A paper presented at the 24th meeting of the American Institute of electrical engineers.
New York, American Institute of electrical engineers. 301 pages (9 1/4 × 5 3/4 inches), illustrated. (Price : $ 1.)

1907 **62.** (02
TULLEY (H. C.).
Handbook on engineering : the practical care and management of dynamos, motors, boilers, engines, pumps, inspirators and injectors.
St. Louis, Mo. Henry C. Tulley & Co. Sixth edition, 16°, 26 + 1,072 pages, il. por. tables, diagrams. (Price : $ 3.50.)

1907 **721** .9
TWELVETREES (W. Noble), M. I. Mech. E.
Concrete-steel buildings.
London and New York, Whittaker & Co. (7 1/4 × 4 7/8 inches), 408 pages, 331 illustrations. (Price : 10*s*.)

1907 **621** .86. (02
WEISBACH (Julius) & **HERRMANN** (Gustav).
The mechanics of hoisting machinery; including accumulators, excavators and piledrivers : a text-book for technical schools and a guide for practical engineers; authorized tr. from 2nd German edition by Karl P. DAHLSTROM.
New York, Macmillan. 8mo, 332 pages, il. (Price : $ 3.)

In Italian.

1906 **621** .13 (02
Delle macchine a vapore ed in particolar modo della locomotiva (Ferrovie dello Stato : Scuole allievi fuochisti).
Roma, tip. del Genio civile. 3 voll. 8°, pag. 123-223-101-fig. con tavola.

1907 **385.** (09.3 (.45)
SPERA (Giuseppe), Ingegnere.
L'esercizio ferroviario in Italia nei suoi rapporti con l'economia del paese e la scienza dei trasporti.
Roma, Tipografia cooperativa sociale. In-8°, 166 pagine. (Prezzo : 5 Lire).

In Russian.

1907 **656** .257
WEISSENBRUCH (L.).
Elektritscheskoe oupravlenie strielkami i signalami w Antwerpenie, po sistemie « Simensa i Halske », Perewel s frantzusk. ing. A. E. BIELOJ.
S. Peterburg, Sklad Isdan. y K. L. Rikkera. Newsky, 14. 8°, 108 stran. s 103 ris. w tekstie. (Stiena : 1 roubl.)

[**016** .385. (05]

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1907 **625** .7

nnales des ponts et chaussées, II, p. 118.

LE GAVRIAN. — Rapport d'ensemble sur les moyens mployés jusqu'ici pour combattre la poussière des outes. (6,000 mots.)

1907 **625** .13

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HAREL DE LA NOÉ. — Consolidation du pont du uildo. (2,200 mots & fig.)

1907 **721** .4

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MESNAGER. — Expériences sur une semi-articulation our voûtes en béton armé. (3,000 mots, tableaux & fig.)

Bulletin de l'Association u Congrès international des chemins de fer. (Bruxelles.)

1907 **385** .61

Bulletin du Congrès des chemins de fer, nº 7, juillet, p. 643.

Troisième conférence internationale pour l'unité echnique des chemins de fer. (6,400 mots & fig.)

1907 **621** .31

ulletin du Congrès des chemins de fer, nº 7, juillet, p. 662.

Utilisation de la force motrice des eaux du Rhin près e Laufenburg. (900 mots & fig.)

1907 **625** .11 (.494 + .45)

ulletin du Congrès des chemins de fer, nº 7, juillet, p. 668.

Le chemin de fer du Splügen. (5,200 mots, 5 tableaux fig.)

1907 **625** .251

ulletin du Congrès des chemins de fer, nº 7, juillet, p. 680.

FOWLER (Geo. L.). — Essais du frein à air Sauvage. 5,600 mots, 2 tableaux & fig.)

1907 **385** .113 (.4)

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COLSON (C.). — Les chemins de fer en 1905-1906. Revue des questions de transports.) (7,400 mots & tableaux.)

1907 **621** .132.3

Bulletin du Congrès des chemins de fer, nº 7, juillet, p. 709.

Locomotive compound du « Mexican National Railway ». (950 mots & fig.)

1907 **656** .257

Bulletin du Congrès des chemins de fer, nº 7, juillet, p. 710.

Nouveau dispositif pour la manœuvre électrique des signaux et des aiguilles en service à la gare de Courcelles-Ceinture, à Paris. (1,450 mots & fig.)

1907 **625** .14 (01

Bulletin du Congrès des chemins de fer, nº 7, juillet, p. 717.

Voie de chemin de fer expérimentale. (1,550 mots.)

1907 **656** .28 (01

Bulletin du Congrès des chemins de fer, nº 7, juillet, p. 720.

Un bureau d'enquête concernant les accidents de chemins de fer. (1,450 mots.)

1907 **385** .581.1

Bulletin du Congrès des chemins de fer, nº 7, juillet, p. 722.

Le repos au Paris-Lyon-Méditerranée. (800 mots.)

1907 **621** .13 & **385**. (04

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Compte rendu bibliographique : Die Dampflokomotiven der Gegenwart. (Les locomotives à vapeur actuelles.) (2,600 mots.)

1907 **016** .385. (02

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Bibliographie mensuelle des chemins de fer. — Livres. (24 fiches.)

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Bulletin du Congrès des chemins de fer, nº 7, juillet, p. 90.

Bibliographie mensuelle des chemins de fer. — Périodiques. (171 fiches.)

Bulletin de la Société d'encouragement pour l'industrie nationale. (Paris.)

1907 **385** .581

Bulletin de la Société d'encourag. pour l'ind. nat., juin, p. 736.

ALFASSA (M.). — La réduction de la journée de travail à huit heures : L'expérience des établissements industriels de l'État. (7,200 mots.)

Bulletin des transports internationaux par chemins de fer. (Berne.)

1907 **385** .63

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Deux nouvelles conventions relatives au transport ternational de marchandises par chemins de fer. ,600 mots.)

Éclairage électrique. (Paris.)

1907 **621** .335

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SOLIER (A.). — Les nouvelles locomotives triphasées la Valteline. (1,400 mots & fig.)

Génie civil. (Paris.)

1907 **624** .8

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BIDAULT DES CHAUMES (A.). — Pont tournant à ux étages sur le port supérieur de Hambourg. (2,600 ots & fig.)

1907 **625** .254

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Frein pneumatique continu renforcé à commande ectrique, système Siemens. (800 mots & fig.)

1907 **621** .87

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GASQUET (R.). — Comparaison entre les grues hydrau- ues et les grues électriques. (3,000 mots & fig.)

1907 **625** .25 (01

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BOYER-GUILLON (A.). — Le freinage des trains à ande vitesse. Nouveau type de frein, système Maximus. 500 mots, 2 tableaux & fig.)

1907 **621** .33 (.73)

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L'électrification du New York Central Railroad dans banlieue de New-York. (1,700 mots & fig.)

Journal des transports. (Paris.)

1907 **385** .113 (.44)

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Les résultats de 1906. — Réseau du Nord. (1,500 ts & 3 tableaux.)

907 **385** .1 (.44)

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e bilan de 1906 des compagnies françaises. (2,000 ts, 4 tableaux & fig.)

1907 **385** .21

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La politique allemande et la navigation intérieure. (2,400 mots)

Nouvelles annales de la construction. (Paris.)

1907 **621** .132.8 & **656** .27

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HEUDE (H.). — Note sur l'emploi des automotrices légères dans l'exploitation des lignes de chemins de fer d'intérêt local et tramways à faible trafic. (1,700 mots.)

Portefeuille économique des machines. (Paris.)

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Portefeuille économique des machines, n° 619, juillet, p. 103.

ESCARD (J.). — L'électro-sidérurgie. (5,800 mots, 1 tableau & fig.)

Revue économique internationale. (Bruxelles.)

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BOISSEVAIN (G. M.). — La crise des chemins de fer aux États-Unis. (4,000 mots)

1907 **621** .33 (.45)

Revue économique internationale, n° 3, juin, p. 545.

TAJANI (P.). — Les essais de traction électrique sur les chemins de fer italiens. (5,400 mots & tableaux.)

1907 **385.** (09.1 (.86)

Revue économique internationale, n° 1, juillet, p. 142.

CASTIAU (M.). — La République de Colombie et ses moyens de transport. (6,700 mots & fig.)

1907 **385** .1

Revue économique internationale, n° 1, juillet, p. 207.

BELLET (D.). — Chronique des transports. (5,700 mots.)

Revue générale des chemins de fer et des tramways. (Paris.)

1907 **385.** (09.1 (.42)

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DEMOULIN & BEZIER. — Note sur le service des trains et des machines en Angleterre. (9,900 mots, 6 tableaux & fig.)

1907 **625** .13 & **691**

Revue générale des chemins de fer, n° 1, juillet, p. 31.

COLLOT. — Note sur des phénomènes de décomposition de mortiers constatés dans divers souterrains du chemin de fer de ceinture de Paris et sur les moyens employés pour en réparer les effets. (5,000 mots, 4 tableaux & fig.)

07 **621** .133.2
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DRIGUE. — Entretoises de foyer en bronze manga-
ou cupro-manganèse. (650 mots & 1 tableau.)

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7 **385** .113 (.4)
générale des chemins de fer, nº 1, juillet, p. 47.

vue des questions de transports. — Les chemins de
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7 **385**. (01 (.5)
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chemin de fer de Bagdad. (2,200 mots & fig.)

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discussion du budget des chemins de fer de l'État
andtag prussien. (2,400 mots.)

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7 **656** .252
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uveau dispositif en usage à la Compagnie de l'Ouest
signaler vers l'arrière les trains dédoublés ou
ordinaires. (350 mots & fig.)

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7 **625** .154
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7 **621** .33 & **625** .4
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and South London ». (300 mots.)

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dilly et Brompton. (1,800 mots & fig.)

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it des réparations des machines américaines. (500
& 1 tableau.)

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7 **621** .132.5 & **621** .134.3
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chauffeur Baldwin. (500 mots & fig.) (V. *Bulletin*
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gons à marchandises du New-York Central. (1,000
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1907 **62**. (01
Revue de mécanique, juin, p. 521.

BREUIL (P.). — Nouveaux mécanismes et nouvelles méthodes pour l'essai des métaux. (7,500 mots & fig.)

1907 **621** .1 (01
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SHULE (W.). — Dynamique de l'écoulement de la vapeur dans les machines à pistons. (8,000 mots & fig.)

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1907 **621** .33 (09.3
Annalen für Gewerbe und Bauwesen, Nr 721, 1. Juli, S. 3.

PETER. — Die geschichtliche Entwickelung der elektrischen Bahnen vom Ursprung bis zu Neuzeit. (6 000 Wörter.)

1907 **621** .135.3 (01
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LINDEMANN (W.). — Das Wogen und Nicken der Lokomotive unter Berücksichtigung der dämpfenden Wirkung der Federn. (2 200 Wörter & Abb.)

1907 **621** .132.8
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GUILLERY (C.). — Neuere Dampfwagen von F. X. Komarek in Wien. (1 400 Wörter, 2 Tabellen & Abb.)

1907 **621** .131.1
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STRAHL. — Ist das Zucken der Lokomotiven eine störende Bewegung? (3 300 Wörter & Abb.)

Archiv für Eisenbahnwesen. (Berlin.)

1907 **385** .112 (.431)
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1907 **385** .517 (.434)
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Wohlfahrtseinrichtungen der königlich württembergischen Verkehrsanstalten. (2 500 Wörter & 1 Tabelle.)

07 **313** .385 (.439)
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07 **313** .385 (.94)
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EISSENBRUCH (L.). — Die einheitlichen verstell-
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07 **625** .253
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ter & Abb.)

1907 **621** .132.8
Bulletin des Eisenbahn-Kongresses, N^r 7, Juli, S. 692.

FRAHM. — Triebwagen und leichte Personenzüge auf den englischen Eisenbahnen. (1 500 Wörter & Abb.)

1907 **621** .132.5 & **621** .134.3
Bulletin des Eisenbahn-Kongresses, N^r 7, Juli, S. 698.

Baldwin-Lokomotive der Santa-Fe-Type mit Ueberhitzer für die « Pittsburg, Shawmut & Northern Railway ». (1 050 Wörter & Abb.)

1907 **621** .33 (.42)
Bulletin des Eisenbahn-Kongresses, N^r 7, Juli, S. 702.

Die Metropolitan District-Eisenbahn. (1 700 Wörter.)

1907 **621** .33 (.45)
Bulletin des Eisenbahn-Kongresses, N^r 7, Juli, S. 707.

Einführung des elektrischen Betriebes auf den Italienischen Bahnen. (100 Wörter.)

1907 **656** .222.1
Bulletin des Eisenbahn-Kongresses, N^r 7, Juli, S. 707.

Zuggeschwindigkeit und die mit ihr verbundenen Gefahren. (1 900 Wörter.)

1907 **656** .28 (01
Bulletin des Eisenbahn-Kongresses, N^r 7, Juli, S. 711.

Ein Untersuchungsamt über Eisenbahn-Unfälle. (2 000 Wörter.)

1907 **621** .13 (02 & **385**. (04
Bulletin des Eisenbahn-Kongresses, N^r 7, Juli, S. 716.

Bücherschau : Locomotive compounding and superheating (Verbundsystem und Ueberhitzung bei den Lokomotiven), von J. F. GAIRNS. (400 Wörter.)

1907 **621** .13 & **385**. (04
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Bücherschau : Les locomotives à l'Exposition de Liége (1905) (Die Lokomotiven auf der Ausstellung in Lüttich [1905]), von A. HERDNER. (200 Wörter.)

1907 **016** .385. (02
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Monatliches Verzeichnis der Eisenbahnliteratur. — Bücher. (24 Zettel.)

1907 **016** .385. (05
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Monatliches Verzeichnis der Eisenbahnliteratur. — Zeitschriften. (171 Zettel.)

Organ für die Fortschritte des Eisenbahnwesens in technischer Beziehung. (Wiesbaden.)

1907 **625** .236
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STABY. — Die Reinigung der Personenwagen. (550 Wörter & Abb.)

1907 **621** .33 (.460)
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GUILLERY (C.). — Die erste elektrisch betriebene Eisenbahn in Spanien. (1 700 Wörter.)

1907 **625** .175
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HONEMANN (A.). — Gleisfahrrad. (1 200 Wörter & Abb.)

1907 **625** .151
Organ für die Fortschritte des Eisenbahnw., 5. Heft, S. 95.

LAMBERT (A.). — Gerade und gekrümmte Weichenstrassen mit Weichen 1 : 11. (3 300 Wörter, 6 Tabellen & Abb.)

1907 **725** .31
Organ für die Fortschritte des Eisenbahnw., 5. Heft, S. 102.

Der neue Bahnhof der Pennsylvania-Eisenbahn in New York. (800 Wörter & Abb.) (S. *Bulletin du Congrès des chemins de fer*, n° 10, octobre 1906.)

1907 **656** .255 & **656** .256
Organ für die Fortschritte des Eisenbahnw., 5. Heft, S. 106.

Der Blockstab von Webb und Thompson in seiner neuesten Form. (900 Wörter & Abb.)

1907 **656** .257
Organ für die Fortschritte des Eisenbahnw., 6. Heft, S. 109.

SCHEPP. — Die elektrischen Stellwerke auf dem Bahnhofe Schwerte. (3 300 Wörter, 1 Tabelle & Abb.)

1907 **625** .143.4
Organ für die Fortschritte des Eisenbahnw., 6. Heft, S. 115.

Stossfangschienen. (650 Wörter & Abb.) (S. *Bulletin du Congrès des chemins de fer*, n° 9, septembre 1906.)

1907 **625** .245
Organ für die Fortschritte des Eisenbahnw., 6. Heft, S. 117.

KOPPEL (A.). — Selbstentlader von 50 t Ladefähigkeit. (350 Wörter & Abb.)

1907 **656** .256
Organ für die Fortschritte des Eisenbahnw., 6. Heft, S. 118.

PFEIL (R.). — Elektrische oder mechanische Abhängigkeit zwischen Streckenblock und Signalen. (650 Wörter.)

1907 **625** .216
Organ für die Fortschritte des Eisenbahnw., 6. Heft, S. 119.

SALLER (H.). — Stosswirkungen im Eisenbahnbetriebe. (800 Wörter & Abb.)

1907 **625** .13
Organ für die Fortschritte des Eisenbahnw., 6. Heft, S. 122.

Die Pennsylvania-Tunnel unter dem Hudson-Flusse. (1 100 Wörter & Abb.)

1907 **625** .142.2
Organ für die Fortschritte des Eisenbahnw., 6. Heft, S. 123.

Förderung der Verwendung von Holzschwellen. (550 Wörter.)

1907 **621** .132.8
Organ für die Fortschritte des Eisenbahnw., 6. Heft, S. 124.

Dampf-Triebwagen. (500 Wörter, 2 Tabellen & Abb.)

1907 **656** .255 & **656** .256
Organ für die Fortschritte des Eisenbahnw., 6. Heft, S. 127.

Die Blocksignale der Berliner Hoch- und Untergrund-Bahn. (650 Wörter & Abb.)

Schweizerische Bauzeitung. (Zürich.)

1907 **656** .256
Schweizerische Bauzeitung, Nr 26, 29. Juni, S. 318.

BEUTLER (J.). — Ein Gefahrpunkt der Streckenblockeinrichtung. (900 Wörter & Abb.)

1907 **624** .63
Schweizerische Bauzeitung, Nr 26, 29. Juni, S. 319.

Eisenbahnbrücke in armiertem Beton über die Rhone bei Chippis im Kanton Wallis. (800 Wörter, 1 Tabelle & Abb.)

1907 **625** .13
Schweizerische Bauzeitung, Nr 1, 6. Juli, S. 6.

CRUGNOLA (G.). — Bauausführung des Gattico-Tunnels im Zuge der Santhià-Borgomanero-Arona-Bahn. (2 400 Wörter & Abb.)

1907 **621** .133.5
Schweizerische Bauzeitung, Nr 1, 6. Juli, S. 10.

HÖHN (E.). — Versuche mit Kamin und Blasrohr an Lokomotiven. (600 Wörter, 1 Tabelle & Abb.).

1907 **625** .111
Schweizerische Bauzeitung, Nr 2, 13. Juli, S. 19.

LÜSCHER (G.). — Die projektierte Zugspitzebahn. (1 600 Wörter & Abb.)

1907 **625** .254
Schweizerische Bauzeitung, Nr 2, 13. Juli, S. 25.

Bremsprobefahrten am Arlberg mit der selbsttätigen Vakuum-Güterzugsbremse. (800 Wörter & Abb.)

1907 **621** .116
Schweizerische Bauzeitung, Nr 4, 27. Juli, S. 41.

SULZER (C.). — Wärmespannungen und Rissbildungen. (3 000 Wörter & Abb.)

Zeitschrift für Kleinbahnen. (Berlin.)

1907 **313 : 625** .61 (.4)
Zeitschrift für Kleinbahnen, Heft 7, Juli, S. 477.

ŽEŽULA (F.). — Statistik der schmalspurigen Eisenbahnen für das Betriebsjahr 1904-1905. (2 000 Wörter & Tabellen.)

Zeitschrift des österreichischen Ingenieur- und Architekten-Vereines. (Wien.)

1907 **656** .231 (.439)
Zeit. des öst. Ingen.- und Archit.-Ver., Nr 27, 5. Juli, S. 485.
— — — — Nr 28, 12. — S. 502.

NÁDORY (N.). — Kritische Besprechung des bei den ungarischen Staatsbahnen eingeführten Zonentarifes mit einem Vorschlag zur Verbesserung desselben. (2 900 Wörter, 11 Tabellen & Abb.)

Zeitschrift des Vereines deutscher Ingenieure. (Berlin.)

1907 **624** .8
Zeitsch. des Vereines deutscher Ingen., Nr 26, 29. Juni, S. 1014.

WEYLAND (R.). — Schwimmende Brücke mit Schiffsdurchlass. (2 200 Wörter & Abb.)

1907 **62.** (01 & **721** .9
Zeitsch. des Vereines deutscher Ingen., Nr 26, 29. Juli, S. 1027.

BACH (C.). — Zur Frage der Dehnungsfähigkeit des Betons mit und ohne Eiseneinlagen. (2 000 Wörter, 1 Tabelle & Abb.)

1907 **621** .131
Zeitsch. des Vereines deutscher Ingen., Nr 27, 6. Juli, S. 1046.
— — Nr 29, 20. — S. 1141.

JAHN (J.). — Der Antriebvorgang bei Lokomotiven. (3 000 Wörter & Abb.)

1907 **621** .33
Zeitsch. des Vereines deutscher Ingen., Nr 27, 6. Juli, S. 1058.

REICHEL (W.). — Die Einführung des elektrischen Zugbetriebes auf den Berliner Stadt-, Ring- und Vorortbahnen. (2 300 Wörter & Abb.)

1907 **621** .116
eitsch. des Vereines deutscher Ingen., Nr 30, 27. Juli, S. 1165.

SULZER (C.). — Wärmespannungen und Rissbildungen. (3 000 Wörter & Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1907 **656** .231 (.489)
Zeitung des Vereins, Nr 50, 3. Juli, S. 793.

SCHULZE (W. A.). — Die Eisenbahntarifreform in Dänemark vom Jahre 1903 und der Ertrag der dänischen Staatsbahnen in den Betriebsjahren 1902-1903 bis 1905-1906. (1 800 Wörter.)

1907 **656** .222.1 (.73)
Zeitung des Vereins, Nr 51, 6. Juli, S. 805.

TROSKE (L.). — Nochmals der Empire State express. (1 400 Wörter & 1 Tabelle.)

1907 **656** .253
Zeitung des Vereins, Nr 52, 10. Juli, S. 821.

CAUER (W.). — Zur Kennzeichnung der Rangierwege. (1 100 Wörter.)

1907 **625** .4
Zeitung des Vereins, Nr 53, 13. Juli, S. 833.

VOSS. — Schwebebahn oder Standbahn? (3 000 Wörter.)

1907 **656** .235.1
Zeitung des Vereins, Nr 54, 17. Juli, S. 845.

BÜSS (G.). — Der Annahmeschluss für Frachtstückgüter bei den preussisch-hessischen Staatseisenbahnen. (3 000 Wörter.)

1907 **656** .237
Zeitung des Vereins, Nr 56, 24. Juli, S. 873.

Vereinfachte Abrechnung im Güterverkehr. (2 200 Wörter.)

1907 **385** .517.7
Zeitung des Vereins, Nr 56, 24. Juli, S. 875.

Unterkunftsräume für Streckenarbeiter. (3 000 Wörter & Abb.)

1907 **625** .144.4
Zeitung des Vereins, Nr 57, 27. Juli, S. 889.

BAUER. — Verwendung der Lokomotivasche (Schlacke) bei der Erhaltung des Oberbaues. (1 700 Wörter & Abb.)

Zentralblatt der Bauverwaltung. (Berlin.)

1907 **625** .13
Zentralblatt der Bauverwaltung, Nr 57, 13. Juli, S. 382.

ZIPLER. — Die Auswechslung der eisernen Ueberbauten der Eisenbahnbrücke über die Elbe bei Magdeburg. (1 000 Wörter & Abb.)

In English.

American Engineer and Railroad Journal. (New York)

1907 **625** .235
nerican Engineer & R. Journal, July, p. 260.

All steel passenger service cars. (1,200 words & fig.)

American Machinist. (New York.)

1907 **62**. (01 & **669** .1
nerican Machinist, No. 26, July 13, p. 908.

STROMEYER (C. E.). — The effect of ageing on mild eel. (3,500 words, 3 tables & fig.)

ulletin of the International Railway Congress Association. (Brussels.)

1907 **656** .253
illetin of the Railway Congress, No. 7, July, p. 667.

WEISSENBRUCH (L.). — Note on the standard nvertible semaphore signals of the Belgian State ilways. (7,200 words & fig.)

1907 **621** .133.2
lletin of the Railway Congress, No. 7, July, p. 709.

RAGNO (S.). — On repairing the tube-plates of loco- otive fire-boxes. (6,700 words & fig.)

1907 **656** .256 (.73)
letin of the Railway Congress, No. 7, July, p. 728.

overnment report on the block-system in the United tes. (4,500 words.)

907 **621** .132.3 & **621** .132.5
letin of the Railway Congress, No. 7, July, p. 736.

ocomotives for the Italian Government Railways. 0 words & fig.)

907 **625** .232
letin of the Railway Congress, No. 7, July, p. 741.

teel passenger car, New York Central & Hudson er Railroad (3,000 words & fig.)

907 **621** .133.4
etin of the Railway Congress, No. 7, July, p. 751.

moke prevention apparatus for locomotives (Staby em). (1,350 words & fig.)

07 **625** .253
etin of the Railway Congress, No. 7, July, p. 756.

he M triple valve. (1,300 words & fig.)

1907 **625** .14 (01
Bulletin of the Railway Congress, No. 7, July, p. 760.

An experimental railway track for testing purposes. (1,300 words.)

1907 **656** .28 (01 (.42)
Bulletin of the Railway Congress, No. 7, July, p. 762.

YORKE (H. A.). — British practice in railroad accident inquiries and railroad inspection. (2,000 words.)

1907 **016** .385. (02
Bulletin of the Railway Congress, No. 7, July, p. 87.

Monthly bibliography of railways. — Books. (24 labels.)

1907 **016** .385. (05
Bulletin of the Railway Congress, No. 7, July, p. 90.

Monthly bibliography of railways. — Periodicals. (171 labels.)

Engineer. (London.)

1907 **625** .14 (01 & **625** .2 (01
Engineer, No. 2687, June 28, p. 657.

Wheel and rail. (1,100 words.)

1907 **621** .132.8
Engineer, No. 2687, June 28, p. 660.

Steam railway motor carriage for India. (500 words & fig.)

1907 **625** .216 (.73) & **656** .25 (.73)
Engineer, No. 2687, June 28, p. 664.

Railway safety appliances in America. (2,300 words.)

1907 **621** .132.3
Engineer, No. 2688, July 5, p. 18.

Express passenger engine, Midland Railway. (700 words & fig.)

1907 **621** .132.3 & **656** .222.1
Engineer, No. 2689, July 12, p. 27.

ROUS-MARTEN (C.). — New type of Great Western express engine : an evolution. (2,100 words & fig.)

1907 625 .61
Engineer, No. 2689, July 12, p. 40.

Light railways. (950 words.)

1907 725 .31
Engineer, No. 2691, July 26, p. 81.

The Pennsylvania new terminus, New York. (1,200 words & fig.) (S. *Bulletin of the International Railway Congress*, No. 10, October 1906.)

Engineering. (London.)

1907 **621** .132.3
ngineering, No. 2165, June 28, p. 852.

Four-cylinder compound express locomotive; Danish tate Railways. (1,600 words, 1 table & fig.)

1907 **624** .8
ngineering, No. 2166, July 5, p. 15.

Bascule bridge for the corporation of Portsmouth. 00 words & fig.)

1907 **385**. (01 (67)
ngineering, No. 2168, July 19, p. 67.

The longest narrow-gauge light railway in the world. 2,200 words & fig.)

1907 **625** .142.1
Engineering, No. 2168, July 19, p. 83.

Railway sleepers. (1,500 words.)

1907 **621** .131.3 & **656** .222.1
Engineering, No. 2169, July 26, p. 98.

The work of the " experiments " on the London & North Western Railway. (2,800 words.)

1907 **625** .13
Engineering, No. 2169, July 26, p. 99.

The Italian approaches to the Simplon tunnel. (4,000 words & fig.)

1907 **625** .616
Engineering, No. 2169, July 26, p. 105.

Six-wheel coupled locomotive (metre-gauge) for the Federated Malay States Railways. (350 words & fig.)

1907 **656** .221
Engineering, No. 2169, July 26, p. 114.

The resistance of Railway trains. (2,200 words, 1 table & fig.)

Engineering Magazine. (London.)

1907 **385**. (01 (.675)
Engineering Magazine, July, p. 571.

BOULGER (D. C.). — The railways of the Upper ongo. (3,000 words & fig.)

Engineering News. (New York.)

1907 **621** .134.3
Engineering News, No. 25, June 20, p. 676.

Results of use of different valve gears on locomotives. 1,900 words.)

1907 **624**. (0
Engineering News, No. 25, June 20, p. 681.

An extensometer for recording deformations in bridge members under impact stress. (1,000 words & fig.)

1907 **621** .133.3
Engineering News, No. 25, June 20, p. 689.

Locomotive fireboxes with expansion side sheets. (1,300 words & fig.)

1907 **621** .331
Engineering News, No. 26, June 27, p. 699.

HARDESTY (W. P.). — The water and electric power systems of the Portland Railway Light and Power Company, Portland, Oregon. (6,000 words & fig.)

1907 **62**. (01
Engineering News, No. 1, July 4, p. 2.

DUDLEY (C. B.) — The enforcement of specifications. (8,500 words.)

1907 **625** .144.4
Engineering News, No. 2, July 11, p. 25.

CORY (H. T.). — Gravel spreader used on the Colorado River levee construction. (900 words & fig.)

1907 **656** .211.7
Engineering News, No. 2, July 11, p. 39.

The Ligderwood electric friction-drum winches for car ferries. (1,300 words & fig.)

1907 **624** .8
Engineering News, No. 3, July 18, p. 56.

Some new bascule bridges. (1,600 words & fig.)

Journal of the Franklin Institute. (Philadelphia.)

1907 **669** .1
Journal of the Franklin Institute, June, p. 407.

CAMPBELL (W.). — Change of structure in iron and steel. (4,500 words, tables & fig.)

Journal of the Western Society of Engineers. (Chicago.)

1907 **625** .233. (01
Journal of the West. Society of Engin., No. 2, April, p. 203.

HUELS (F. W.). — Vibrations in passenger trains from high speed electric lighting engines. (7,000 words, 4 tables & fig.)

1907 **621** .116
Journal of the West. Society of Engin., No. 3, June, p. 285.

BRECKENRIDGE (L. P.). — A review of the United States geological survey fuel tests under steam boilers. (20,000 words & fig.)

1907 **721** .9
ournal of the West. Society of Engin., No. 3, June, p. 349.

HOTCHKISS (L. J.). — Some details of concrete onstruction. (7,200 words & fig.)

1907 **621** .331
urnal of the West. Society of Engin., No. 3, June, p. 373.

SCHUCHARDT (R. F.). — The rotary converter sub-ation. (8,000 words & fig.)

1907 **621** .332
urnal of the West. Society of Engin., No. 3, June, p. 409.

SMITH (E. F.). — The development and operation of large electric transmission and conversion system. 2,000 words & fig.)

Locomotive Firemen and Enginemen's Magazine. (Indianapolis.)

1907 **621** .135.5
ocomotive Firemen and Enginemen's Magazine, July, p. 45.

WOOD (W. W.). — Some irregularities of the et ngine and tender brake equipment. (6,300 words & fig.)

Locomotive Magazine. (London.)

1907 **621** .132.1 (.73)
ocomotive Magazine, No. 179, July 15, p. 124.

Modern American locomotives. (200 words & fig.)

Page's Weekly. (London.)

1907 **625** .143.2
age's Weekly, No. 148, July 12, p. 60.

TALBOT (B.). — Rail steel, manufactured by the ntinuous openhearth process. (1,000 words, 1 table fig.)

Proceedings of the Institution of Civil Engineers. (London.)

1906/1907 **625** .13
roceedings of the Inst. of Civil Eng., vol. CLXVIII, p^{t} II, p. 61.

FOX (F.). — The Simplon tunnel. (18,000 words, bles & fig.)

1907 **656** .211 & **656** .212
roceedings of the Inst. of Civil Eng., vol. CLXVIII, p^{t} II, p. 169.

ROYAL-DAWSON (F. G.). — The design of wayside ations for single lines of railway. (7,500 words & fig.)

1907 **624** .2 (01
roceedings of the Inst. of Civil Eng., vol. CLXVIII, p^{t} II, p. 189.

LLOYD-JONES (C. W.). — Distribution of stresses in late-girders. (10,000 words, 3 tables & fig.)

Railroad Gazette. (New York.)

1907 **621** .133.1
Railroad Gazette, No. 23, June 7, p. 764.

EMERSON (H.). — A solution of the oil-burning locomotive problem. (2,500 words & fig.)

1907 **621** .132.3
Railroad Gazette, No. 23, June 7, p. 774.

De Glehn compound for the Paris-Orleans Railway. (1,600 words & fig.)

1907 **621** .132.8
Railroad Gazette, No. 23, June 7, p. 778.

Gasolene motor cars for railroad service. (2,300 words.)

1907 **621** .134.3 & **621** .132.5
Railroad Gazette, No. 23, June 7, p. 780.

The Baldwin superheater. (400 words & fig.)

1907 **625** .176
Railroad Gazette, No. 23, June 7, p. 782.

WELLS (R.). — Changing the gage on the Louisville & Nashville. (1,900 words & fig.)

1907 **621** .132.3
Railroad Gazette, No. 23, June 7, p. 784.

Pacific locomotive for the Atlanta & West Point. (1,000 words & fig.)

1907 **621** .134.1 (01
Railroad Gazette, No. 23, June 7, p. 787.

MANNING (H. G.). — Compression in locomotive cylinders and means for its relief. (2,000 words & fig.)

1907 **621** .134.3
Railroad Gazette, No. 23, June 7, p. 792.

Superheated steam on locomotives. (2,400 words.)

1907 **621** .135.4 & **625** .144.2
Railroad Gazette, No. 23, June 7, p. 795.

HENDERSON (G. R.). — Moment of inertia and curvature. (1,600 words & fig.)

1907 **625** .14 (01
Railroad Gazette, No. 23, June 7, p. 801.

CUENOT (G.). — Track deformations and their prevention. (1,800 words.)

1907 **385** .114
Railroad Gazette, No. 23, June 7, p. 802.

FRY (L. H.). — The cost of locomotives, 1890-1907. (2,100 words & fig.)

907 **625** .253
lroad Gazette, No. 23, June 7, p. 804.
— No. 24, — 14, p. 862.

ARKE (F. H) & DUDLEY (S. W.). — Recent develop-
ts in air brake control apparatus. (5,200 words
g)

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907 **725** .33
road Gazette, No. 24, June 14, p. 824.

team and electric locomotive terminals of the
York Central at Croton and North White plains.
00 words & fig.)

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907 **621** .338
lroad Gazette, No. 24, June 14, p. 831.

IAZELTON (H.). — The new steel cars of the Hudson
npanies. (2,100 words & fig.)

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907 **624** .8
lroad Gazette, No. 24, June 14, p. 836.

KSTROM (A. R.). — Page single-leaf double-track
cule railroad bridge over the Chicago River. (1,000
ds & fig.)

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907 **625** .235
lroad Gazette, No. 24, June 14, p. 846.

teel passenger cars for the Pennsylvania Railroad.
00 words & fig.)

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907 **621** .32 & **625** .233
lroad Gazette, No. 24, June 14, p. 866.

lectric train lighting. (3,600 words.)

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907 **656** .254
lroad Gazette, No. 26, June 28, p. 935.

h · telemagnophone. (250 words & fig.)

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907 **625** .14 (01
lroad Gazette, No. 26, June 28, p. 939.

ailroad track of the present and its possible future
elopment. (1,500 words & fig.)

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907 **621** .132.4
lroad Gazette, No. 1, July 5, p. 6.

en-wheel locomotive for the Chicago & North
stern. (1,000 words & fig.)

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907 **624** .8
road Gazette, No. 1, July 5, p. 10.

all bascule bridge over the Illinois River at Peoria.
words & fig.)

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907 **656** .211
lroad Gazette, No. 1, July 5, p. 15.

roposed New Union passenger station at Buffalo.
0 words & fig.)

1907 **625** .13
Railroad Gazette, No. 2, July 12, p. 44.

Progress of the Pennsylvania tunnels under Manhattan Island. (1,800 words & fig.)

1907 **656** .253
Railroad Gazette, No. 3, July 19, p. 63.

New top-mast motor signal. (800 words & fig.)

1907 **621** .33 (.73)
Railroad Gazette, No. 3, July 19, p. 67.

The New York Central's electric lines. (1,700 words & fig.)

1907 **721** .4 (01
Railroad Gazette, No. 4, July 26, p. 90.

HOWE (M. A.). — The symmetrical masonry arch; analysis according to the elastic theory. (900 words & 2 tables.)

1907 **621** .13 (09.3 (.73)
Railroad Gazette, No. 4, July 26, p. 97.

CARUTHERS (C. H.). — Early years of the Philadelphia & Reading. (5,200 words & fig.)

Railway Age. (Chicago.)

1907 **625** .235
Railway Age, No. 1619, June 21, p. 1180.

Pennsylvania steel passenger cars. (1,700 words & fig.)

1907 **625** .143.2
Railway Age, No. 1620, June 28, p. 1204.

Standard specifications for steel rails. (1,200 words & fig.)

1907 **62**. (01
Railway Age, No. 1620, June 28, p. 1205.

DUDLEY (C. B.). — The enforcement of specifications. (2,800 words.)

1907 **625** .143.2
Railway Age, No. 1620, June 28, p. 1207.

DUDLEY (P. H.). — Mechanical experiences with limber and stiff rail sections. (2,700 words & fig.)

1907 **385** .111 (.73)
Railway Age, No. 1620, June 28, p. 1210.

Depreciation and per diem charges in new accounting system. (2,500 words.)

1907 **621** .32 & **625** .233
Railway Age, No. 1620, June 28, p. 1218.

GILMAN (C. R.). — Storage battery developments in train lighting service. (2,400 words & fig.)

1907 **621** .132.5
ilway Age, No. 1620, June 28, p. 1222.

Consolidation locomotive for the Chicago Rock Island Pacific. (300 words & fig.)

1907 **625** .245
ilway Age, No. 1621, July 5, p. 7.

New dynamometer car of the Pennsylvania Railroad. 300 words & fig.)

1907 **385** .1 (.73)
ilway Age, No. 1622, July 12, p. 46.

PROUT (H. G.). — Agitation against the railroads. 200 words.)

1907 **625** .175
.ilway Age, No. 1622, July 12, p. 66.

Automatic track inspector. (300 words & fig.)

Railway Engineer. (London.)

1907 **621** .132.5
ilway Engineer, No. 330, July, p. 197.

New 8-coupled (2-8-0) compound engines; St. Gothard ilway. (500 words & fig.)

1907 **625** .232
ilway Engineer, No. 330, July, p. 198.

Invalid saloons; L. and North Western Railway. (700 rds & fig.)

.907 **625** .232
ilway Engineer, No. 330, July, p. 213.

Third class dining cars; Great Central Railway. (800 rds & fig.)

907 **621** .133.3
lway Engineer, No. 330, July, p. 219.

ocomotive boilers with wide fireboxes. (1,200 words ig.)

907 **656** .28 (01
lway Engineer, No. 330, July, p. 227.

fficial reports on recent accidents. (8,400 words ig.

Railway and Engineering Review. (Chicago.)

907 **625** .24 (01
lway and Engineering Review, No. 25, June 22, p. 552.

ractical means for increasing the earning capacity of ight cars. (4,200 words.)

1907 **656** .223
Railway and Engineering Review, No. 25, June 22, p. 559.

BARDO (C. L.). — Science of freight transportation. (3,800 words.)

1907 **625** .143.2 & **62**. (01
Railway and Engineering Review, No. 26, June 29, p. 570.

The steel rail discussion, American Society for testing materials. (8,800 words & 2 tables.)

1907 **621** .132.3
Railway and Engineering Review, No. 26, June 29, p. 575.

Very heavy Pacific type locomotive for the Pennsylvania R. R. (450 words & fig.)

1907 **625** .14 (01
Railway and Engineering Review, No. 26, June 29, p. 578.

SCHAUB (J. W.). — Possible development of railway track. (1,600 words & fig.)

1907 **62**. (01
Railway and Engineering Review, No. 26, June 29, p. 581.

The enforcement of specifications. (900 words.)

1907 **625** .143.2
Railway and Engineering Review, No. 26, June 29, p. 582.

TALBOT (B.). — Rail steel manufactured by the continuous open-hearth process. (1,000 words & fig.)

1907 **625** .143.2
Railway and Engineering Review, No. 26, June 29, p. 583.

DUDLEY (P. H.). — Mechanical experiences with limber and stiff rails. (2,900 words & fig.)

1907 **625** .245
Railway and Engineering Review, No. 27, July 6, p. 590.

New dynamometer car, P. R. R. (2,500 words & fig.)

1907 **656** .24
Railway and Engineering Review, No. 28, July 13, p. 622.

Care and co-operation in handling freight traffic. (7,700 words.)

1907 **625** .13 (.73)
Railway and Engineering Review, No. 29, July 20, p. 640.

Tunnel construction in and about New York City. (6,500 words & fig.)

Railway Gazette. (London.)

1907 **625** 253
Railway Gazette, No. 26, June 28, p. 614.

PARKE (F. H.) & DUDLEY (S W). — Recent developments in air brake control apparatus. (2,400 words & fig.)

1907 **621 .32 & 625 .233**

ailway Gazette, No. 26, June 28, p. 618.

Electric train lighting. (3,600 words.)

1907 **385. (01 (.51)**

ilway Gazette, No. 1, July 5, p. 20.

The great interior trunk line of China. (2,400 words fig.)

1907 **621 .132.7**

ilway Gazette, No. 2, July 12, p. 39.

New 0-8-4 tank shunting engines, Great Central ailway. (300 words & fig.)

1907 **625 .14 (01**

ailway Gazette, No. 2, July 12, p. 41.

Railroad track of the present and its possible future velopment. (1,500 words & fig.)

1907 **621 .13 (09.3**

ailway Gazette, No. 3, July 19, p. 55.

RICHES (T. H.). — Locomotive engineering in 1907. ,000 words & fig.)

1907 **625 .143.3**

ailway Gazette, No. 3, July 19, p. 57.

Wear of steel rails. (1,800 words, 3 tables & fig.)

1907 **656 .211**

ailway Gazette, No. 3, July 19, p. 63.

Proposed New Union passenger station at Buffalo. ,000 words & fig.)

1907 **621 .132.5**

ailway Gazette, No. 4, July 26, p. 81.

New type of 0-8-0 locomotive, Hull & Barnsley Rail-ay. (450 words & fig.)

1907 **625 .13**

ailway Gazette, No. 4, July 26, p. 83.

Tunnel ventilation. (700 words & fig.)

1907 **625 .13**

ailway Gazette, No. 4, July 26, p. 88.

Progress of the Pennsylvania tunnels under Manhattan sland. (1,800 words & fig.)

Railway Machinery. (New York.)

1907 **621 .131.3**

ailway Machinery, July, p. 595.

Altoona locomotive testing plant, Pennsylvania Rail-oad. (1,100 words & fig.)

Railway Magazine. (London.)

1907 **656 .222.1 (.42)**

Railway Magazine, No. 121, July, p. 12.

ROUS-MARTEN (C.) — British locomotive practice and performance. (3,700 words & fig.)

Railway Maintenance and Structures. (New York.)

1907 **625 .17**

Railway Maintenance and Structures, June, p. 104.

DUFOUR (F. O.). — Maintenance of way. (4,700 words.)

Railway Times. (London.)

1907 **725 .43**

Railway Times, No. 3, July 20, p. 57.

The Swindon works of the Great Western Railway. (2,000 words & fig.)

Railway World. (Philadelphia.)

1907 **385 .1 (.73)**

Railway World, No. 26, June 28, p. 544.

FISH (S.). — Some phases of the railroad problem. (4,500 words.)

1907 **625 .143.2**

Railway World, No. 29, July 19, p. 612.

The steel rail problem. (3,000 words & fig.)

Statist. (London.)

1907 **385 .1 (.42)**

Statist, No. 1532, July 6, p. 21.

British railways. (1,900 words.)

Street Railway Journal. (New York.)

1907 **621 .33**

Street Railway Journal, No. 1, July 6, p. 4.

HEWITT (J. R.). — A. C. electrification on the Illinois traction system. (4,400 words, 1 table & fig.)

1907 **621 .332**

Street Railway Journal, No. 1, July 6, p. 16.

CUNNINGHAM (E. R.). — The effect of the transmission line upon the reliability and efficiency of electric interurban railway service. (2,100 words & fig.)

1907 **621 .33**

Street Railway Journal, No. 2, July 13, p. 62.

The plans of the Boston & Eastern Electric Railroad. (6,000 words, 3 tables & fig.)

Tramway & Railway World. (London.)

907 **621** .33 & **625** .4
mway & Railway World, July, p. 1.

haring Cross, Euston and Hampstead Railway. 00 words & fig.)

In Italian

Ingegneria ferroviaria. (Roma.)

907 **621** .132.1 (.42)
egneria ferroviaria, nº 13, 1º luglio, p. 210.

LAKE (C. E.). — Le locomotive a quattro cilindri in hilterra. (2,600 parole & fig.)

907 **621** .33
egneria ferroviaria, nº 14, 16 luglio, p. 230.

ERRETI (U.). — La ferrovia elettrica di Val Bremna. (1,200 parole & fig.)

907 **621** .132.4
egneria ferroviaria, nº 14, 16 luglio, p. 233.

VALENZIANI (I.). — Alcune recenti locomotive a pore soprariscaldato dello Stato prussiano. (700 parole fig.)

In Spanish

Gaceta de los caminos de hierro. (Madrid.)

907 **656** .234
ceta de los caminos de hierro, nº 2648, 1º de julio, p. 298.

La nueva tarifa de billetes kilométricos. (1,400 palabras cuadro.)

1907 **625** .142.2
Gaceta de los caminos de hierro, nº 2649, 8 de julio, p. 315.
— — — nº 2650, 16 — p. 326.

La conservación de las traviesas de los caminos de hierro. (1,800 palabras & 2 cuadros.)

Revista de obras públicas. (Madrid.)

1907 **656** .222.1 (.43 + .73)
Revista de obras públicas, nº 1658, 4 de julio, p. 385.

Velocidad de los trenes en los ferrocarriles americanos y alemanes. (4,200 palabras.)

1907 **624** .62 (01
Revista de obras públicas, nº 1659, 11 de julio, p. 399.

Cálculos de estabilidad de puentes metálicos en arco con piso superior y con articulaciones en los arranques. (4,400 palabras, 5 cuadros & fig.)

1907 **621** .33
Revista de obras públicas, nº 1660, 18 de julio, p. 414.
— — — nº 1661, 25 — p. 427.

MARIÑO (Don R. T.). — Ventajas de la traccion electrica en los ferrocarriles. (4,800 palabras.)

Transportes ferreos. (Madrid.)

1907 **625** .611 (.460)
Transportes férreos, nº 910, 8 de julio, p. 5365.

Reforma de la ley de ferrocarriles secundarios (2,200 palabras.)

Vol. XXI. — No. 10. October, 1907. 12th Year of the English Edition.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .251]

NOTE

ON THE NEW IRON POSTS USED BY THE BELGIAN STATE RAILWAY FOR WIRE TRANSMISSIONS FOR OPERATING SIGNALS,

By L. WEISSENBRUCH,
CHIEF ENGINEER,
SIGNALLING SUPERINTENDENT, BELGIAN STATE RAILWAY,

and L. KIRSCH,
CHIEF ENGINEER,
ASSISTANT SIGNALLING SUPERINTENDENT, BELGIAN STATE RAILWAY.

Figs. 1 to 13, pp. 973 and 974.

Owing to the increased speed of trains, the signals, and particularly the distant signals, are further and further from the points from which they are operated. This general phenomenon has of late led the Belgian State Railway to improve all the details of their wire transmissions.

Owing to the increased distance of operation, it is very important to use steel wire of great tensile strength, to reduce the friction of the sheaves on their pins and of the wires on the sheaves, to have jointed connections for the latter so that their position may be adjusted accurately, and to have very rigid supports for them.

For the latter purpose, the former posts made of old wood of small cross-section no longer suffice; oak uprights fixed to a strong base are required to do the work satisfactorily. Such oak posts are expensive, and have not a long life. It is very difficult to find any inexpensive device making it possible, once the posts are fixed, to adjust the sheave about two perpendicular planes, so as to fix it in a true position. The plane perpendicular to the axis and intersecting it at its centre must in fact contain the wire which is to be guided. This latter part of the problem can only be solved practically with iron posts.

Posts of this kind have already been in regular use for some time in some countries, more particularly in Holland and in Germany. However, they satisfy requirements but incompletely. The part sunk below the earth has insufficient stability and is generally made of rolled iron, so that it rusts rapidly unless it is protected by concrete, which is somewhat expensive. The collars to which the sheaves are secured are kept in position by set screws which work loose or the threads of which become broken. In the patterns which consist of an upright tube screwed into a cast iron base, the connection between these two parts is not sufficiently reliable, in spite of the use of some form ot strut or stay.

The new post adopted by the Belgian State Railway consists of three chief parts : a base of grey cast iron, which is let into the ground so that its top is flush with the surface, an upright consisting of a tube of square section, of rolled or drawn iron or steel, which projects above the surface, and an arm which is a malleable or steel casting; the latter supports the blocks.

The cast iron base A (figs. 1 to 7) is so shaped that it can, according to the nature of the ground, be placed either direct into it, or on to a base of wood, or into a block of concrete. It is shaped and dimensioned so as to have much greater resistance both vertically and laterally than the usual wooden posts. At the top it has a deep square opening, into which the bottom of the upright takes.

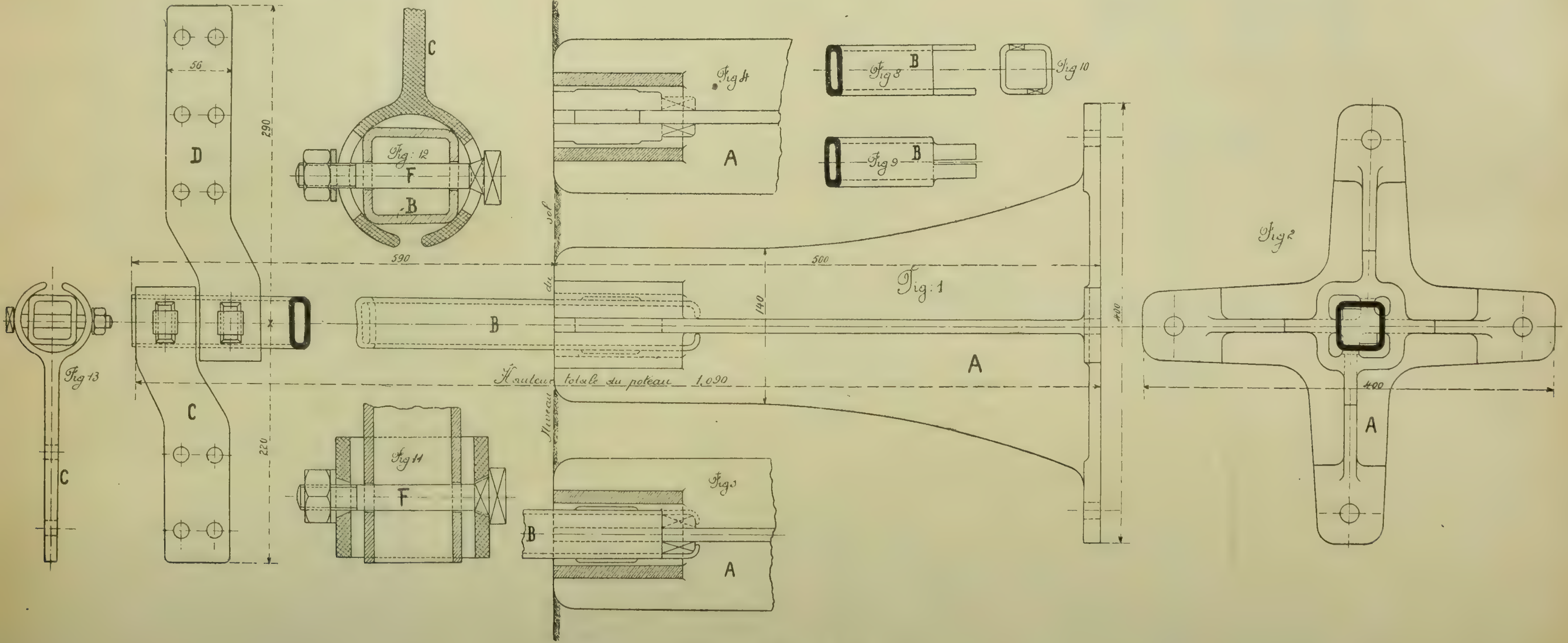
The upright B (figs. 1, 2 and 5 to 12) consists of a simple tube of square section, of the usual rolled or drawn pattern. Its lower end is cut so as to leave two projecting tongues (figs. 8 to 10); it is introduced hot into the top of the base and gently driven in; then the two tongues are bent and take under two projections which are in the casting.

Thus joined, the base and upright form together one rigid united whole.

The upper part of the upright has two round holes drilled through it for the bolts F which fix the arms (figs. 11 and 12).

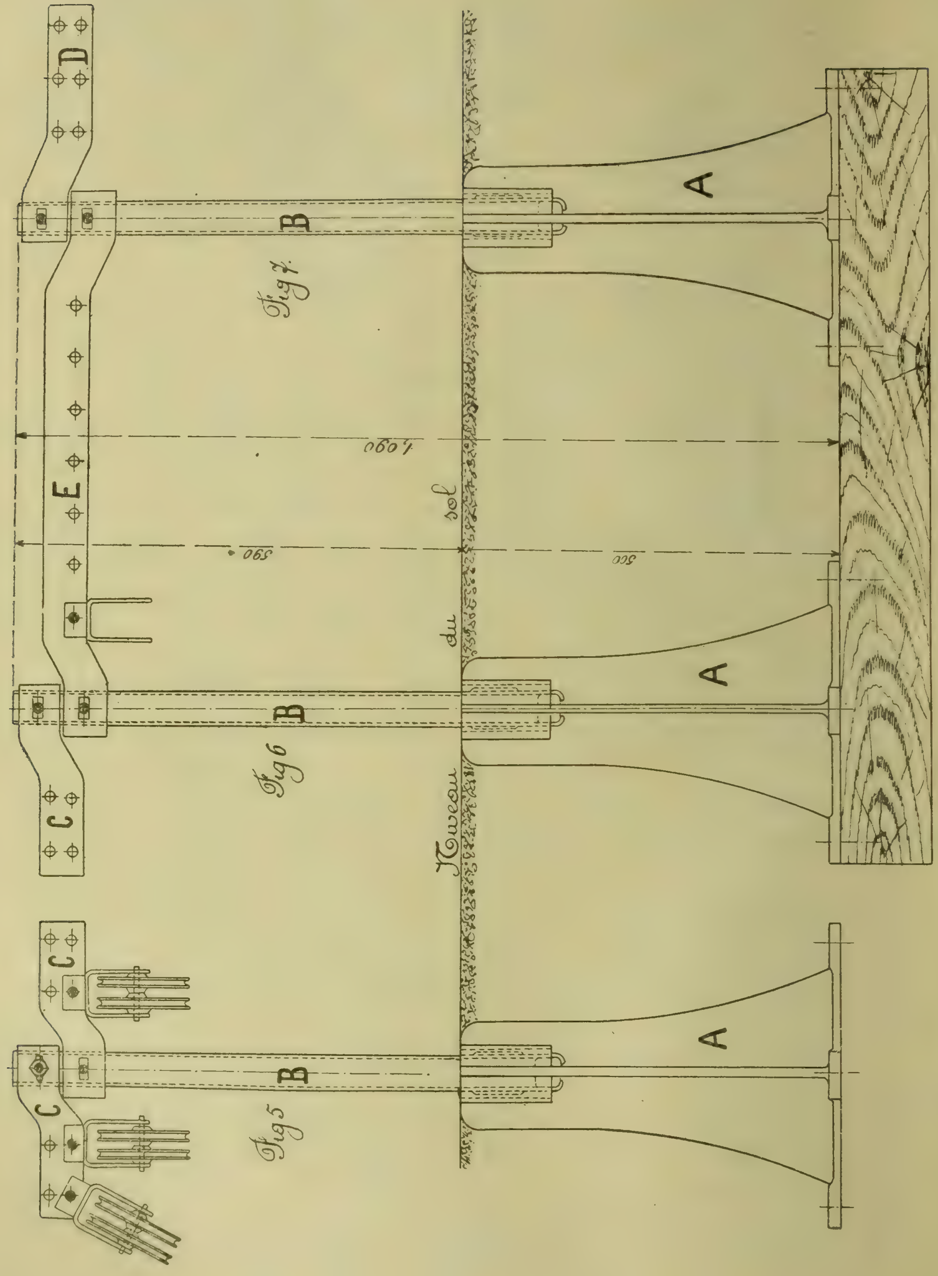
The arms C, D, E (figs. 1, 5, 6, 7, 11, 12 and 13) are malleable or steel castings, and support the blocks. At the one end they end in a split sleeve, just large enough to slip over the end of the upright, while exercising a certain amount of elastic pressure on it. The sleeve has two oval holes through which the fixing bolt passes. When the bolt is slack, the arm can be rotated to a certain extent about the upright, and after proper adjustment is then fixed in its final position.

By means of this very simple device, any want of accuracy in fixing the post is quickly and easily corrected; the arms can be fixed at right angles to the transmission wires, and consequently, the central plane of the sheaves can be made to pass exactly through the wire which is to be guided; in this way any friction between the wire and the sides of the groove of the sheave is eliminated, and the sheaves are so constructed that they can be fixed at any angle required; consequently, the wire is no longer subjected to any stress by them.



Figs. 1 to 4 and 8 to 13.

Explanation of French terms : Hauteur totale du poteau = Total height of the post. — Niveau du sol = Ground level.



Figs. 5 to 7.

The arms are of three types, for two, three and seven blocks respectively. By suitable arrangement it is thus possible to support from one to thirteen blocks, that is to say, from one to twenty-six transmission wires, as may be desired.

These posts, which are made entirely of metal and of good material, hardly cost more than new oak posts of equal strength but having no means of ajustment. Their life is evidently much longer than that of oak posts, even of pickled oak posts, and when worn out they are still worth from 40 to 50 per cent of their original price.

[621 .133.7]

APPARATUS FOR PREVENTING THE FORMATION OF COHERENT SCALE IN BOILERS,

By Mr GÖLSDORF,

CHIEF COUNCILLOR, AUSTRIAN STATE RAILWAY.

Figs. 1 to 4, pp. 977 and 978.

The appliance we are going to describe, is based on the following observations :

1° Considerable amounts of scale are always deposited in boilers at the places where the feed water enters, no matter whether it enters directly into the boiler after going through the feed valve, or whether it first passes through a certain length of tube after going through the valve.

2° At these places, the water coming from the injection suddenly loses the greater part of its velocity, and its temperature is very quickly raised from about 100° to nearly 200° C. (from about 212° to nearly 392° Fahr.).

There is no doubt that the deposit of scale mentioned under 1° is due to the combined effect of the two phenomena mentioned under 2°; and it may logically be proposed to increase the effect of both so as to make the water, as soon as it enters the boiler, precipitate the greater part of the impurities it contains. This would make it possible to collect the precipitate in a receptacle easy to clean.

Figures 2, 3 and 4 show the appliance as fitted to several express locomotives of the Austrian State Railway (series 206). Two cast-iron receptacles A, each made in two pieces for convenience of fitting, are placed one on each side of the set of tubes, so as to be completely immersed in the water ; rectangular openings are provided in the upper side opposite to the hole O through which the feed water enters.

At the end of each run (about 100 miles), the mud-cocks C are opened, the injectors having previously been turned on so as to keep up a strong pressure in the receptacles and blow out the deposits.

The following results have been obtained with this device :

The water used for the locomotives of series 206 is such that in order to prevent priming the boilers had to be washed out every eight days; the locomotives fitted with this appliance run fourteen days before it is necessary to clean the boilers. Hard scale is no longer formed, but only soft mud which is removed without difficulty.

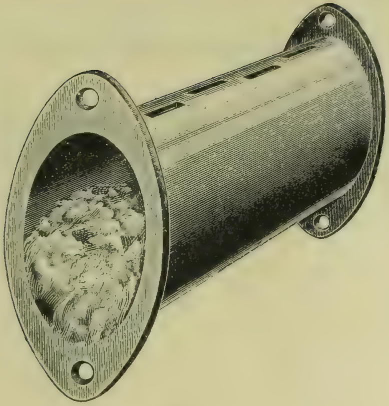


Fig. 1.

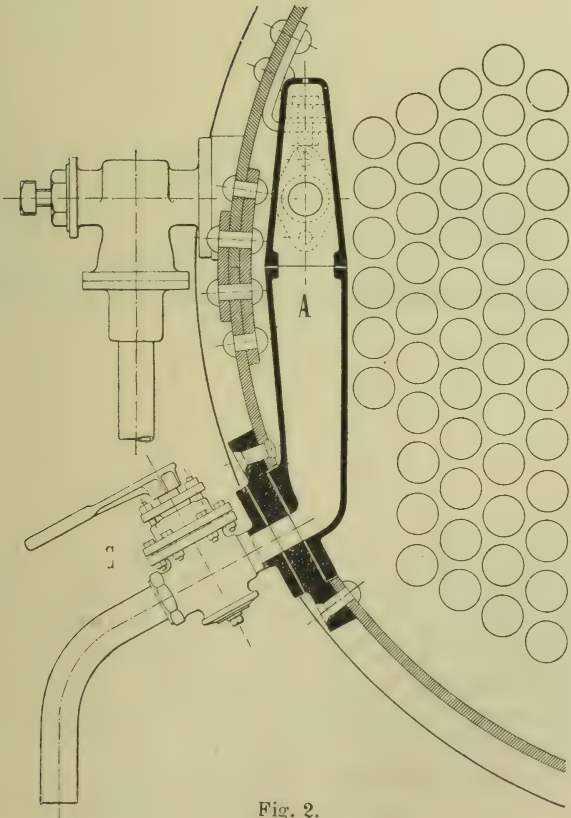


Fig. 2.

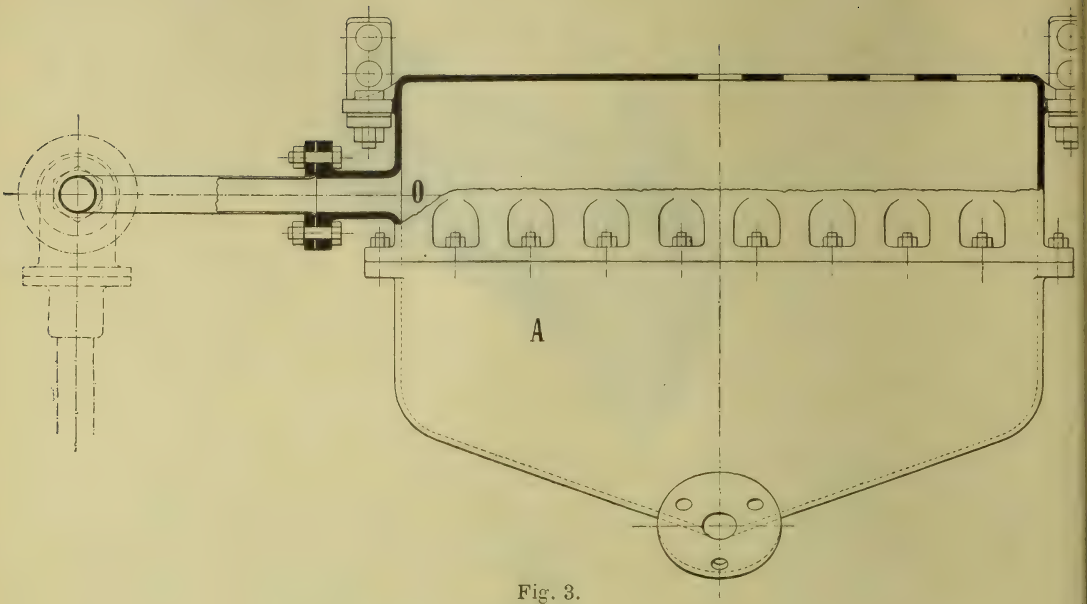


Fig. 3.

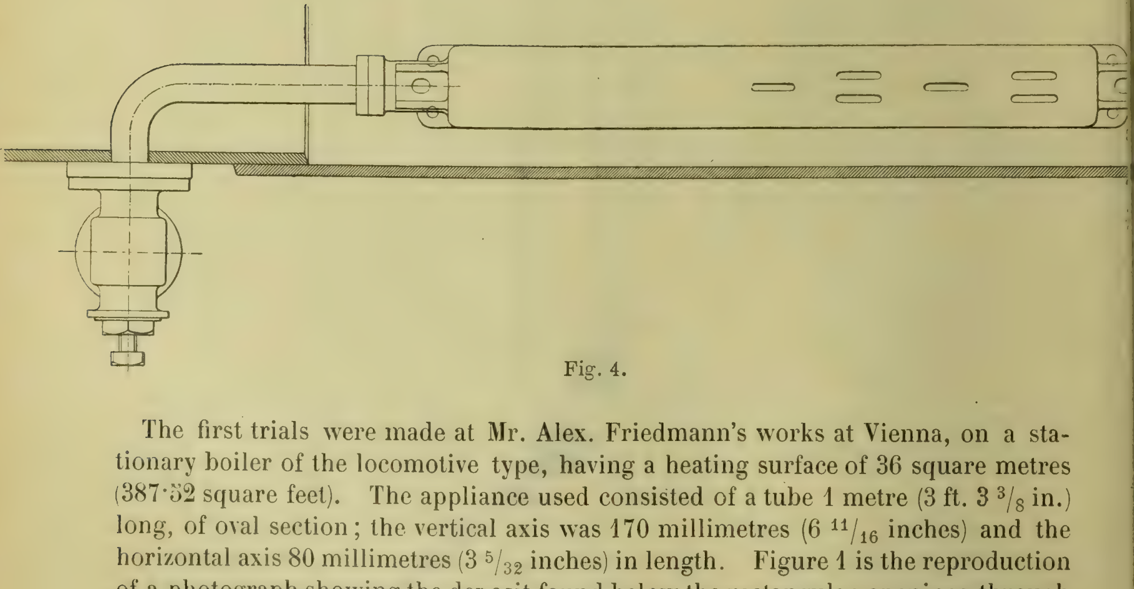


Fig. 4.

The first trials were made at Mr. Alex. Friedmann's works at Vienna, on a stationary boiler of the locomotive type, having a heating surface of 36 square metres (387·52 square feet). The appliance used consisted of a tube 1 metre (3 ft. 3 $^3/_8$ in.) long, of oval section; the vertical axis was 170 millimetres (6 $^{11}/_{16}$ inches) and the horizontal axis 80 millimetres (3 $^5/_{32}$ inches) in length. Figure 1 is the reproduction of a photograph showing the deposit found below the rectangular openings through which the water passes, after thirty hours' use.

The examination of this deposit showed that the apparatus had not only induced the separation of the solid particles suspended in the water, but had also caused the precipitation of the dissolved salts which produce scale, such as calcium and magnesium carbonate, and calcium sulphate; chemical analysis showed that these three substances were present in the deposit in about the same relative proportions as in the feed water.

The most important point is the precipitation of the magnesia, which no previous water-softening apparatus was able to remove; now it is well known that it is the presence of this substance which induces the calcium salts to form a hard and coherent scale.

[625 .253 (.01)]

VIBRATIONS IN PASSENGER TRAINS FROM HIGH SPEED ELECTRIC LIGHTING ENGINES,

(Paper and discussion.)

By F. W. HUELS.

Presented December, 1906.

Figs. 1 to 20, p. 981 to 992.

(*Journal of the Western Society of Engineers.*)

I. — PAPER.

The vibrations in passenger trains caused by the reciprocating action of the high speed engine of the electric generating sets, constitutes one of the principal objections to their use, These engines produce vibrations that are sometimes of considerable magnitude owing to lack of perfect balance of the reciprocating parts. The vibrations are transmitted back into the train, since the whole train is elastic. Thus a source of annoyance to the passengers is created which railways would be glad to get rid of, and steam turbines are now replacing reciprocating engines in the train lighting field, because they have the advantage of no vibration.

It is interesting and of some importance to know something about the magnitude and character of these vibrations. So far as is known to the writer, no attempt has been made, up to the present, to make measurements of them. In the following pages the results of tests of this kind are presented.

Method of locating generating sets as adopted by various roads.

In figures 1 and 2 is shown the method of locating the generating set as adopted by the Chicago, Milwaukee & St. Paul Railway Company. Here the engine is placed crosswise in the baggage car and as close to the locomotive as possible. This location is at a point about 3 feet ahead of the forward king bolt. It is claimed that in this way the piping between the locomotive and the lighting engine is reduced to a minimum length, thereby reducing the condensation of steam in the pipe to a minimum.

The Chicago & Northwestern Railway and the Northern Pacific Railway adopt the arrangement shown in figures 3 and 4. Here the generator is placed so that the shaft is parallel to the

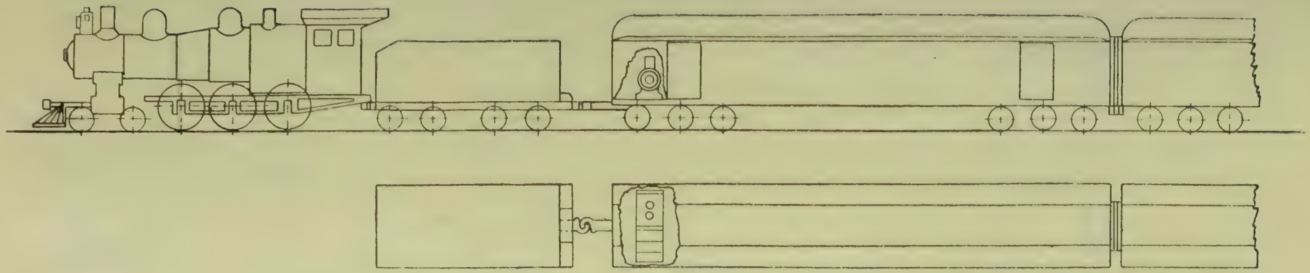


Fig. 1. -- Method of placing engine set -- Chicago, Milwaukee & St. Paul Railway Company.

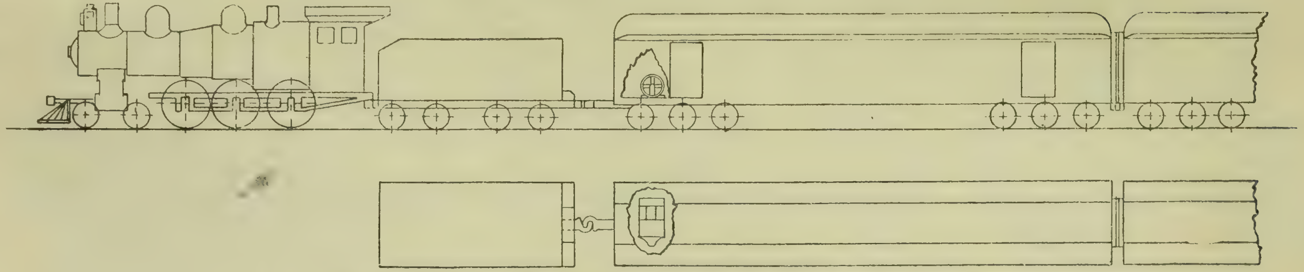


Fig. 2. — Method of placing turbine set. -- Chicago, Milwaukee & St. Paul Railway Company.

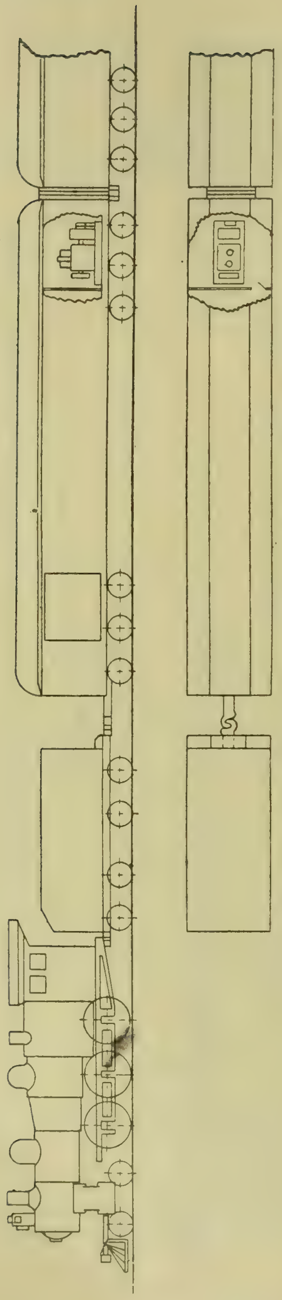


Fig. 3. — Method of placing engine set. — Chicago & Northwestern Railway.

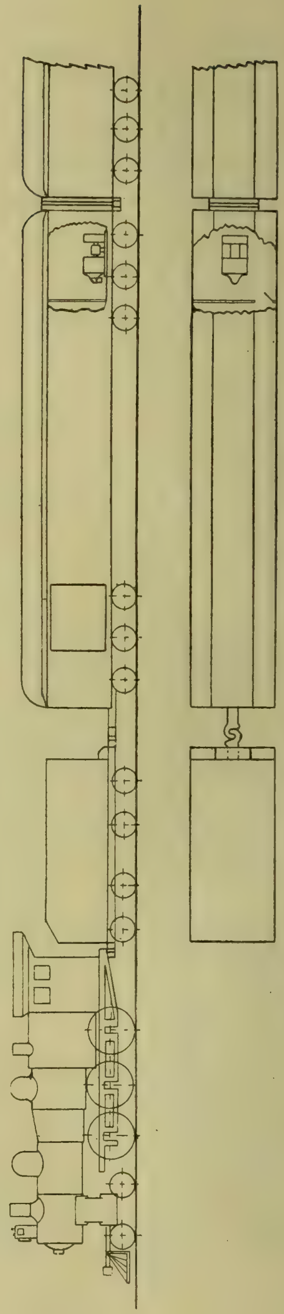


Fig. 4. — Method of placing turbine set. — Chicago & Northwestern Railway.

length of the car and at a point over the rear king bolt. The Chicago & Northwestern Railway uses this system, because the front part of the car is the express compartment and the door leading into it is kept locked. By placing the set in the rear of the car, the electrician can attend to it without disturbing the express man. In this arrangement, the distance between the locomotive and generator is as much as 50 feet, which produces a considerable amount of condensation in the steam pipe.

Further, it has been claimed that the vibrations could be felt further back in the train when the latter arrangement is employed because the " vibration center " is further back in the train. The experiments on vibrations described in this paper seem to bear out this point, as will be observed by making an examination of figure 20.

Vibration indicators and seismographs.

For measuring vibrations of this kind, instruments known as " seismographs " or " seismometers " are used. This name was originally given to instruments constructed to measure the movement of the ground during earthquakes. Webster's dictionary gives these definitions :

" *Seismometer :* An instrument for measuring the direction, duration, and forces of earthquakes and like concussions. "

" *Seismograph ;* An apparatus for registering the shocks and undulatory motions of earthquakes. "

One of the types of earth movements that are recognized and of which measurements are made, consists of :

Sudden displacements or " earth tremors, " resembling earthquakes in the rapidity with which they take place, but differing from them in that they can be detected only by means of instruments on account of the smallness of the motion.

It can be seen that this class of movements or " earth tremors " resembles the vibratory movements caused by the reciprocating engines of train lighting sets. Hence, instruments used to measure this type of movement will be considered further on.

The following notes taken from an article on the *Seismometer* in the *Encyclopædia Britannica* show the principles upon which these instruments are based.

" In the first type of measurements what may be called the " inertia method " is followed. A mass is suspended with freedom to move in the direction of that component of the earth's motion which is to be measured. When an impulse occurs the supports move, but the mass is prevented by its inertia from accompanying them. It supplies a steady point to be used as a standard of reference in determining the extent through which the ground has moved in the direction in question... In all instruments, designed to furnish a steady point, the suspended mass must have some small stability, else it would be unmanageable; but its period of free oscillation must be greater than that of the earthquake motions which it is employed to measure... The whole movement is resolved into rectilinear components, and these are separately recorded. ... on a plate or drum which is kept in continuous movement, so that the record of each component takes the form of an undulating line, from which the number, succession, amplitude, velocity, and acceleration of the component movements can be deduced and the resultant motion determined. "

The vibration indicator used in these tests.

The ordinary types of instruments used to measure earthquakes are not suitable for work on railway trains, because they are over-sensitive, not portable, nor compact. Something less sensitive, but compact and portable, is required. Consequently, the instrument shown in the following pages was developed. It is a modification of the forms already described. The movement, whatever it may be, is resolved into two components, one vertical and the other horizontal.

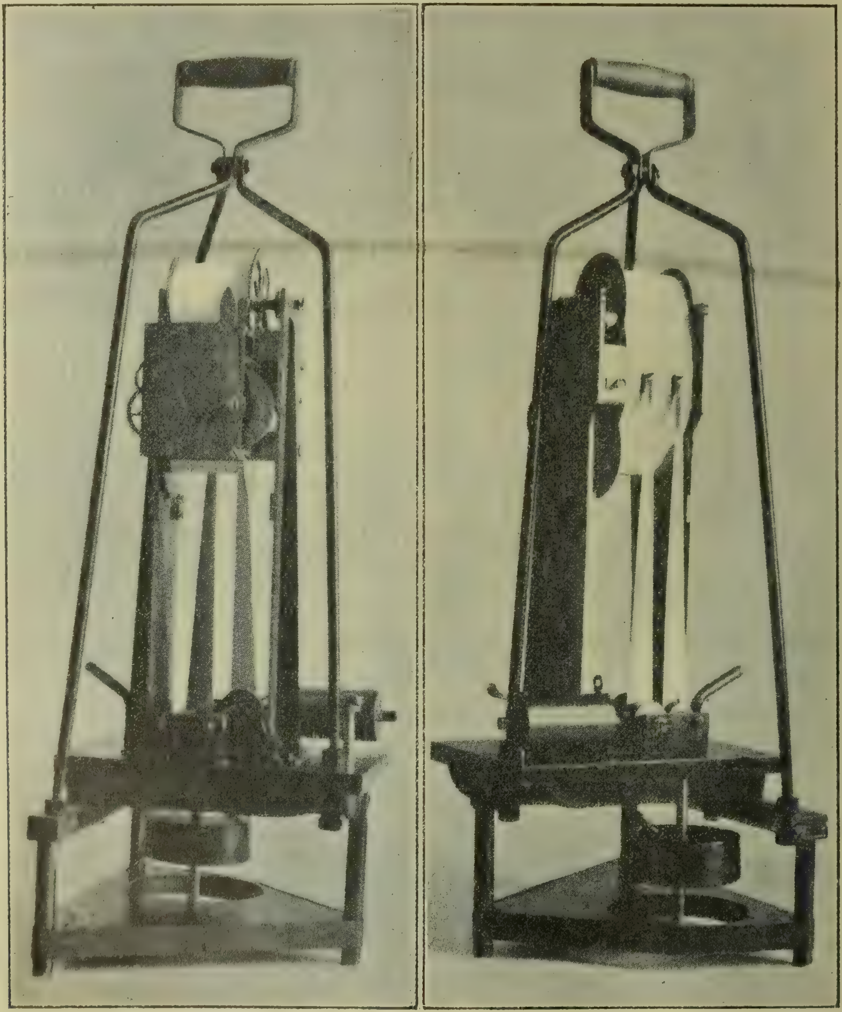


Fig 5. — Rear view.

Fig. 6. — Front view.

Figs. 5 and 6. — Vibration recorder.

The instrument consists of four principal mechanisms which may be described as follows :

1° A mechanism for indicating and magnifying the vertical component of the motion;

2° A mechanism for indicating and magnifying the horizontal component of the motion in one direction;

3° A mechanism for permanently recording both vertical and horizontal components on the same record sheet;

4° A base with suitable framework serving to support mechanisms 1, 2 and 3, and which serves to give stability to the apparatus.

The vertical motion. — The vertical component of the motion is recorded by the device shown in figures 10 and 11.

A cylindrical brass weight, A, weighing 2 pounds, is supported upon the lever, B. The spindle, C, is solidly fastened to B, and at right angles to it, by means of the collar, D. Spindle C is then mounted upon a base by means of the pivots, E and F. At one end of C is the pin, G. Mounted upon C is a coil spring, H, consisting of thirty turns of number 12 iron wire. One end of this spring is fastened around the pin, G, and the other end is solidly soldered into a collar, I. Collar I fits into the support, J, and is so arranged that the torsion of the coil spring can be regulated. A light aluminium pointer, K, carrying a pencil at its upper end, is mounted upon the collar, D. It magnifies the displacement of the weight, A.

The operation of this device is as follows : When A is moved downward and then released, it returns to its normal position. This normal position is horizontal and it is kept there by placing the proper tension upon the spring, H. When A is moved upward, there is a tendency to continue upward. A small spring L may be attached to the pointer, K, its tension being regulated to bring the weight back into its normal position.

Now, for up and down movements of the points, E and F, corresponding to movements of the base of the instrument, some point in A tends to remain stationary on account of the inertia of this weight. As already mentioned, the resulting relative movement is indicated and magnified by the pointer, K, and a record of it is made by the pencil point, M, at the end of the pointer.

It can be seen that a horizontal displacement of the points, E and F, will have no effect upon the weight, A, and will produce no displacement of the pointer, K. Hence, this device records the vertical component of the movements of the base.

The horizontal motion. — The device by means of which the horizontal motion is recorded is shown in figures 12 and 13. Such movements are detected by pendulums.

A spindle, A, is pivoted at the points, B and C. Hanging from the spindle, and rigidly fastened to it, is a circular piece of cast iron, D, weighing 4 $^1/_4$ pounds. An aluminium pointer, E, carrying a pencil point at its upper end, is also fastened to the spindle.

By examining figure 12, it will be seen that when the points, B and C, are quickly moved to the right or left, some point in the weight, D, will remain at rest on account of the inertia of the weight This will cause a multiplied record of the displacement to be made by the pointer, E.

A vertical displacement of the points, B and C, will cause no movement of the pencil point with respect to B and C. Consequently, this contrivance will be unaffected by the vertical component of the motion but will record the horizontal component.

The recording mechanism. — For permanently recording the vibrations, a strip of metallic paper, 2 $^1/_2$ inches wide, is made to pass under the pencil point by means of clock-work. The paper is unwound from one roller and wound upon another.

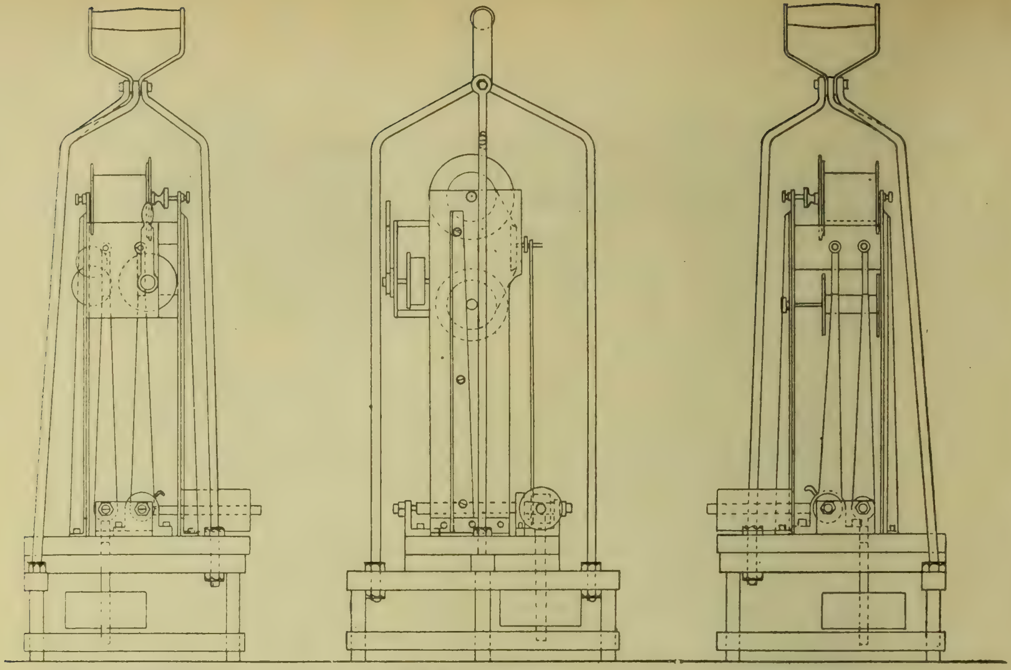


Fig. 7. — Rear view.

Fig. 8. — Side view.

Fig. 9. — Front view.

Figs. 7 to 9. — Sketch of vibration recorder. Scale : $^1/_4'' = 1''$.

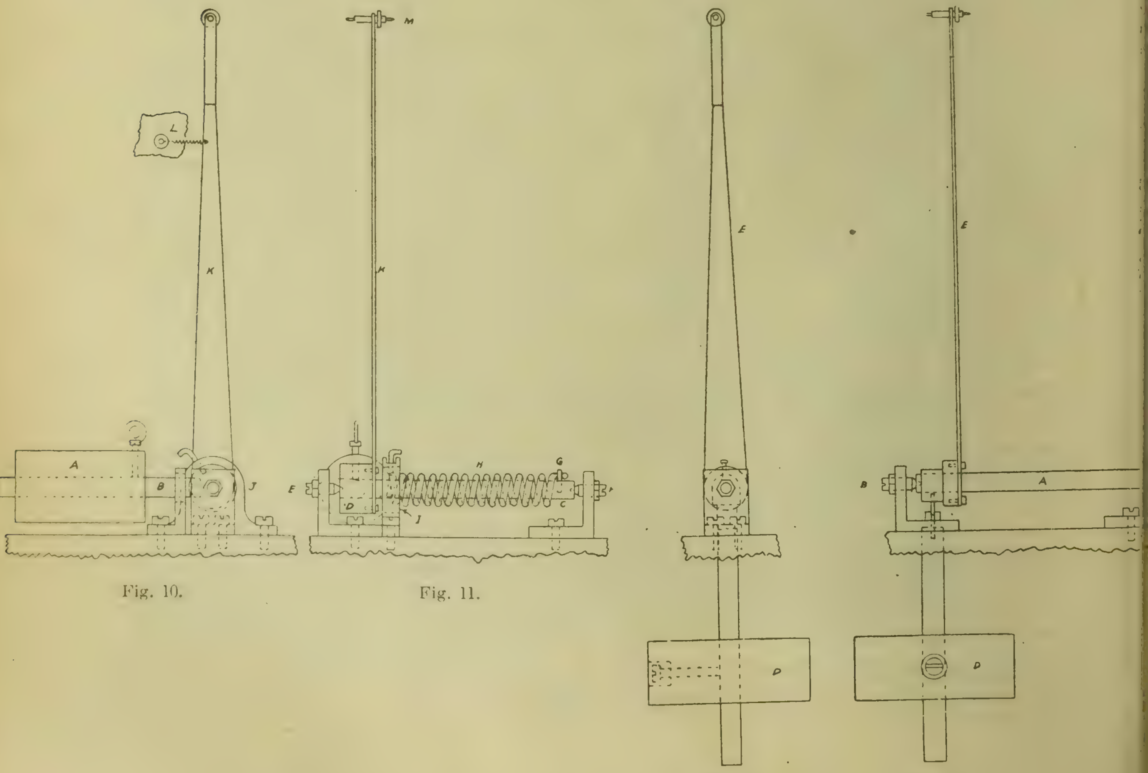


Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Figs. 10 to 13. — Details of the vibration recorder. Scale : $^1/_2'' = 1''$.

Metallic paper and ordinary paper have been used. Brass points, black lead, and indelible copying lead have been used for pencil points. Experience has shown that brass points do not make a satisfactory mark. By using metallic paper and either black lead or indelible lead points, a fine record is obtained on the smooth surface of the metallic paper. A further advantage of using indelible points is that the record may be strengthened and permanently fixed by dampening it. This makes a very satisfactory method.

The base and framework. — These three mechanisms, that for the vertical motion, that for the horizontal motion, and the clock-work for driving the paper, are all supported by the necessary framework upon a heavy iron base. A handle is also provided by means of which the instrument can readily be carried about.

Method of obtaining data.

The instrument the characteristics of which have just been described, was set upon the floor of the car under test and allowed to operate. A record was obtained which showed the horizontal and vertical components of the motion of the car floor at that particular point. The instrument, being portable, was next set up on various cars of the train and at various points on the cars.

For instance, when a record of the vibration of the baggage car, caused by the lighting engine, was desired, a test was made at the time the train had come to a standstill at some station. The instrument was placed, say, 3 feet from the generating set, and operated long enough to obtain a record. It has been carried to the center of the car, then to a point above the rear king bolt of the car or to the rear platform, a record being taken at each of these points. Then, if there was time, it was set up in the second, third, and other cars of the train. As a rule, however, the stops are of short duration and it is impossible to obtain more than one record at each stop. It is only at junction points, at points where water is being taken by the locomotive tender, or while standing in the coach yards, that several records can be made. As a result of this, the records are not all simultaneous.

Trains, cars, and systems which have been tested.

Through the courtesy of the Chicago, Milwaukee & St. Paul Railway Company, and the Chicago & Northwestern Railway Company, it was possible to make tests of the nature and magnitude of the vibrations produced by the generating sets in use on some of their finest trains. The Chicago, Milwaukee & St. Paul Railway Company allowed me to make tests on the *Pioneer Limited*, an electric lighted train running between Chicago and Minneapolis. Similar tests were made on the *Northwestern Limited* of the Chicago & Northwestern Railway Company, running between the same points. It was thus possible to get comparative results.

Tests were made on Westinghouse *Standard* engine sets and Curtis steam turbine generator outfits on both roads. A summary of these may be given as follows :

1° Pioneer Limited, Chicago, Milwaukee & St. Paul Railway Company. 20 kilowatts, Westinghouse Standard Engine & Generator from Milwaukee, Wisconsin, to Tomah, Wisconsin ;

2° Pioneer Limited, Chicago, Milwaukee & St. Paul Railway Company, 25 kilowatts, Curtis Steam Turbine & General Electric Generator from Tomah, Wisconsin, to Milwaukee, Wisconsin ;

3° Northwestern Limited, Chicago & Northwestern Railway Company, 20 kilowatts, Westinghouse Standard Engine & Generator from Madison, Wisconsin, to Minneapolis, Minnesota, and return;

4° Baggage Car, 216, Chicago & Northwestern Railway Company, 25 kilowatts, Curtis Steam Turbine & General Electric Generator, standing in coach yards of the Chicago, St. Paul, Minneapolis & Omaha Railway Company, at Minneapolis, Minnesota.

Results of tests.

In the following pages are given tables and diagrams showing the results of tests made in the manner just described. These data are largely self-explanatory. The vibration was resolved into its horizontal and vertical components and in the diagrams these are shown by the upper and lower curves, respectively. The number of vibrations per minute, the extent of the vibrations, in inches, and remarks relating to the station, position, and time of the record, are given.

These records were taken on trains that were as nearly alike as possible in all respects. 20 kilowatts Westinghouse engines and 25 kilowatts Curtis turbines were tested on both trains, the only difference being that the sets in the case of the Chicago, Milwaukee & St. Paul trains were crosswise and in the front of the baggage car, while, in the Chicago & Northwestern trains they were lengthwise and in the rear of the baggage car.

Figure 20 gives comparative results at various points on the trains. The figures at the top of the records on this sheet indicate the number of the record in figures 16, 17, 18 and 19.

Resumé.

From the experiments recorded in this paper and from general observations it appears that reciprocating engine train lighting sets, as installed at present, produce vibrations of considerable magnitude, due to unbalanced forces set up in them by the reciprocating motion of their parts. Many of you, no doubt, have experienced them while traveling upon electric lighted trains. The waves of vibration thus produced are transmitted back into the train for a distance which depends to some extent not only upon the method of placing the generating set in the car and its position in the train, but also upon the nature and condition of the coupling, buffing, and vestibuling devices. Other factors, some of which are pointed out in what follows, influence the extent of the vibratory waves and the distance of their transmission. The vibration becomes apparent when the train is at rest, but as soon as the train starts and when under way the pitching and tossing of the cars is great enough to destroy the effect of the vibrations caused by the lighting set. It appears from the records that the vibrations produced are of a complex character, and that they can be resolved into components. In this work the vibration of the car floor was resolved into vertical and horizontal components, the horizontal component being determined longitudinally in the car. There is also a lateral horizontal component of the vibration but it is not recorded in this paper since it is of small extent and often absent. Thus, the car vibrates in three dimensions. The component vibrations appear to have a " peaked " wave form and where both components exist there are as many horizontal as there are vertical vibrations.

The vibration frequency is in the neighborhood of 400 per minute and, since the lighting engines run at this speed, it may be said that there is one vibration per revolution of the electric light engine. Or, what is the same thing, there are as many vibrations as there are revolutions. Hence, the number of vibrations depends upon the speed of the lighting engine.

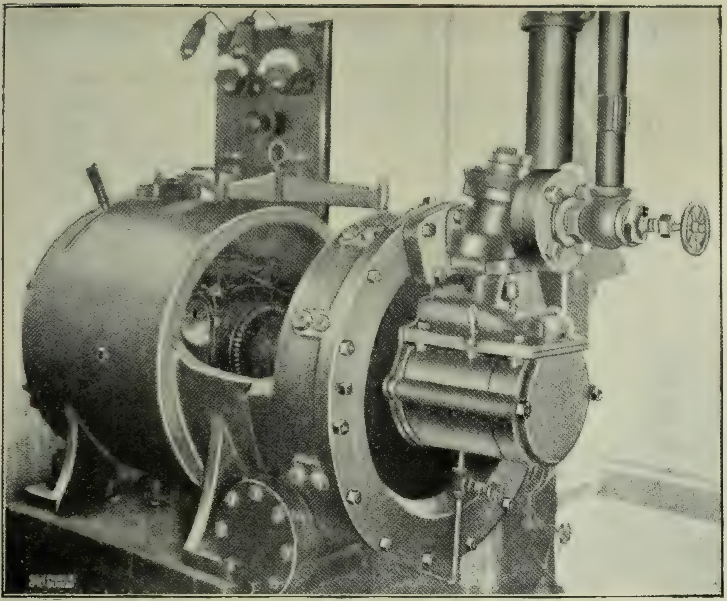


Fig. 14. — 25 kilowatts Curtis turbine generator.

Fig. 15. — Westinghouse engine and generator lighting set.

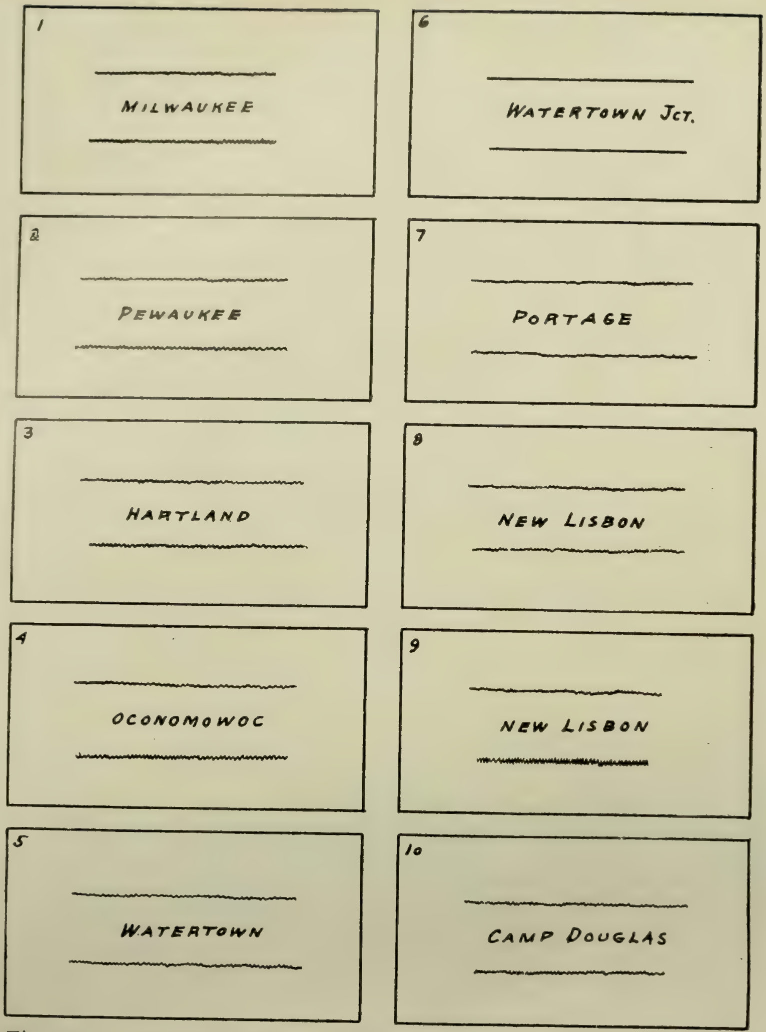


Fig. 16. — *Pioneer Limited.* — Chicago, Milwaukee & St. Paul Railway Company. — Westinghouse standard engine, 20 kilowatts. — Upper = Horizontal; Lower = Vertical. Scale = 2.

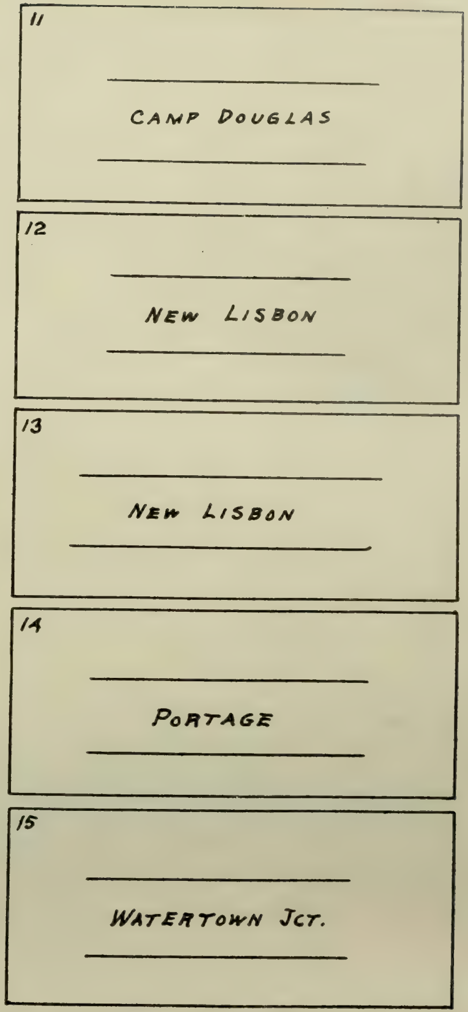


Fig. 17. — *Pioneer Limited.* — Chicago, Milwaukee & St. Paul Railway Company. —

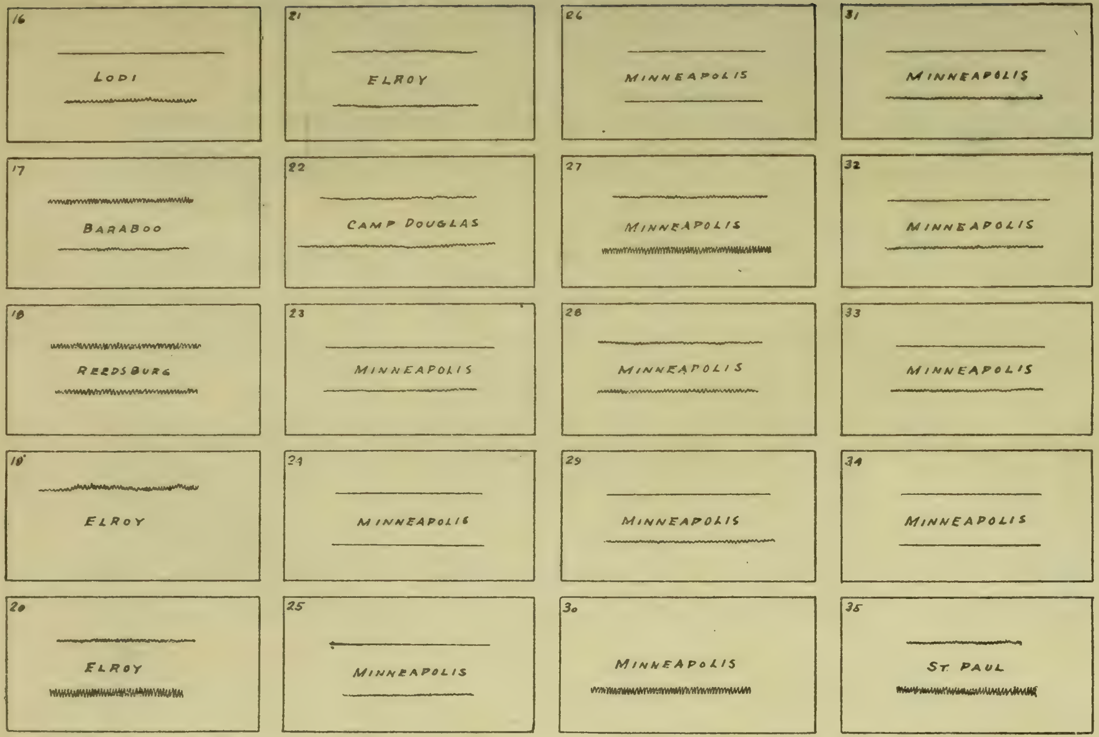


Fig. 18. — *Northwestern Limited.* — Chicago & Northwestern Railway Company. — Westinghouse standard engine, 20 kilowatts. — Upper = Horizontal; Lower = Vertical. Scale = 2.

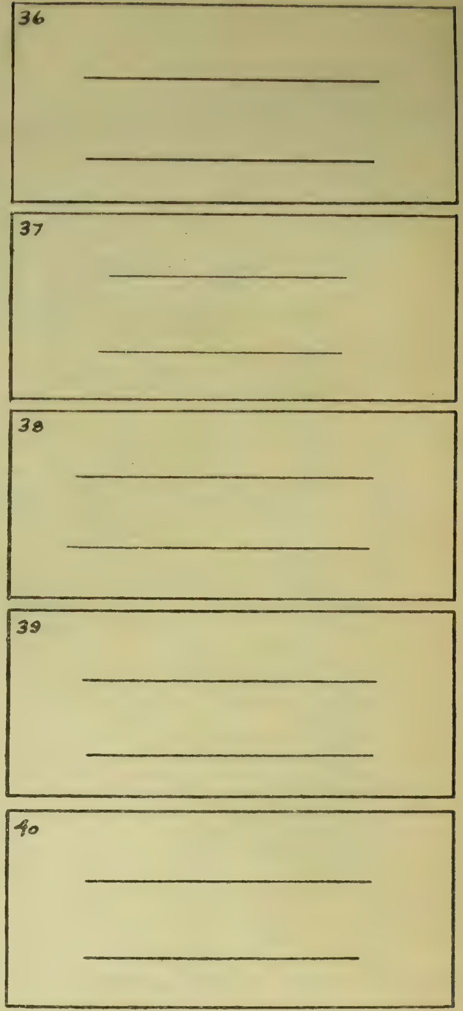
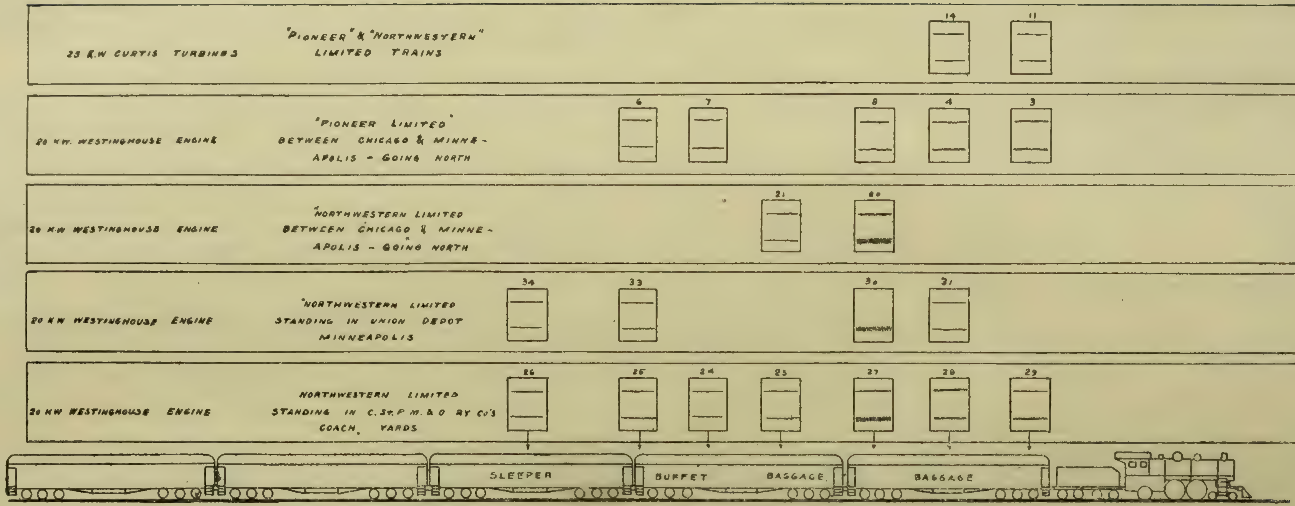


Fig. 19. — Baggage car 216. — Chicago & Northwestern Railway Company. — General Electric Curtis turbine. — Upper = Horizontal; Lower = Vertical. Scale = 2.

Records taken in C. St. P. M. & O. Yards.


25 K.W CURTIS TURBINES
"PIONEER" & "NORTHWESTERN" LIMITED TRAINS
20 K.W. WESTINGHOUSE ENGINE
"PIONEER LIMITED" BETWEEN CHICAGO & MINNEAPOLIS - GOING NORTH
20 K.W WESTINGHOUSE ENGINE
"NORTHWESTERN LIMITED" BETWEEN CHICAGO & MINNEAPOLIS - GOING NORTH
20 K.W WESTINGHOUSE ENGINE
"NORTHWESTERN LIMITED" STANDING IN UNION DEPOT MINNEAPOLIS
20 KW WESTINGHOUSE ENGINE
NORTHWESTERN LIMITED STANDING IN C. St. P. M. & O. RY CO'S COACH YARDS
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SLEEPER
BUFFET
BAGGAGE
BAGGAGE

Fig. 20. — Sketch showing vibration at various points on the train as measured. — Upper curve = Horizontal component; Lower curve = Vertical component.

Table I.

Tests of vibrations caused by a Westinghouse, 20 kilowatts, train lighting set. "Pioneer Limited" Chicago, Milwaukee & St. Paul Railway.

(May 5 and 6, 1906.)

Engine, No. 4245. 7 1/2 × 7 inches, 400 revolutions per minute. — Generator, No. 58538.

RECORD NUMBER.	Vertical.		Horizontal.		Remarks.		
	Number of vibrations per minute.	Extent of vibrations in inches.	Number of vibrations per minute.	Extent of vibrations in inches.	Station.	Position.	Time.
1	410	0·03	410	0·01	Milwaukee	Baggage car. Three feet from engine.	9 : 01 p. m.
2	344	0·03	344	0·01	Pewaukee	Baggage car. Three feet from engine.	9 : 43 p. m.
3	377	0·02	377	0·01	Hartland	Baggage car. Three feet from engine.	9 : 53 p. m.
4	322	0·03	322	0·01	Oconomowoc	Baggage car. Center of car.	10 : 11 p. m.
5	396	0·02	396	0·02	Watertown	Baggage car. Center of car.	10 : 30 p. m.
6	None perceptible.		None perceptible.		Watertown Junction	Buffet car. Rear platform.	...
7	384	0·01	384	0·01	Portage	Buffet car. Center of car.	11 : 55 p. m.
8	405	0·01	405	0·01	New Lisbon	Baggage car. Rear of car.	1 : 14 a. m.
9	374	0·05	374	0·01	New Lisbon	Baggage car. Center of car.	1 : 15 a. m.
10	386	0·02	386	0·01	Camp Douglas	Baggage car. Near generator.	1 : 30 a. m.

Table II.

Tests of vibrations caused by a General Electric, 25 kilowatts, Curtis train lighting set. "Pioneer Limited", Chicago, Milwaukee & St. Paul Railway.

(May 5 and 6, 1906.)

Baggage car, No. 410. — Turbine, No. 3229. — Generator, No. 111775. — Steam pressure, rated, 80 pounds per square inch. — Amperes, 200; volts, No. load, 120; full load, 125.

RECORD NUMBER.	Remarks.		
	Station.	Position.	Time.
11	Camp Douglas	Baggage car. Three feet from engine.	2 : 37 a. m.
12	New Lisbon	Baggage car. Three feet from engine.	2 : 43 a. m.
13	New Lisbon	Baggage car. Center of car.	2 : 51 a. m.
14	Portage	Baggage car. Center of car.	4 : 00 a. m.
15	Watertown Junction.	Baggage car. Center of car.	5 : 25 a. m.

Table IV.

Tests of vibrations caused by a General Electric, 25 kilowatts, Curtis train lighting set. Chicago, St. Paul, Minneapolis & Omaha Railway.

(July 21, 1906.)

Baggage car, No. 216. — Turbine, No. 2907. — Generator, No. 111715.

RECORD NUMBER.	Remarks.		
	Station.	Position.	Time.
36	Minneapolis coach yards	Baggage car. Next to generator.	6 : 30 p. m.
37		Baggage car. Next to generator.	
38		Baggage car. Next to generator.	
39		Baggage car. Center of car.	
40		Baggage car. Center of car.	

Table III.

Tests of vibrations caused by a Westinghouse, 20 kilowatts, train lighting set. “ Northwestern Limited ” Chicago & North Western Railway.

(July 20 and 21, 1906.)

Baggage car, No. 1107. — Engine, No. 4171. 7 1/2 × 7 inches, 400 revolutions per minute. — Generator, No. 52974.

RECORD NUMBER.	Vertical.		Horizontal.		Remarks.		
	Number of vibrations per minute.	Extent of vibrations in inches.	Number of vibrations per minute.	Extent of vibrations in inches.	Station.	Position.	Time.
16	382	0·03	None perceptible.		Lodi	Baggage car (1107). Three feet from engine.	11 : 19 p. m.
17	388	0·02	388	0·03	Baraboo	Baggage car (1107). Three feet from engine.	11 : 55 p. m.
18	403	0·03	403	0·06	Reedsburg	Baggage car (1107). Three feet from engine.	12 : 26 a. m.
19	400	...	400	0·06	Elroy	Baggage car (1107). Three feet from engine.	1 : 05 a. m.
20	400	0·10	400	0·02	Elroy	Baggage car (1107). Three feet from engine.	1 : 10 a. m.
21	400	0·01	400	0·01	Elroy	Baggage car (589). Center of car.	1 : 12 a. m.
22	408	0·03	408	0·02	Camp Douglas	Baggage car (1107). Three feet from engine.	...
23	390	0·01	None perceptible.		Minneapolis coach yards.	Baggage car (589). Center of car.	7 : 00 p. m.
24	None perceptible.		None perceptible.			Buffet car (589). Rear platform.	
25	390	0·01	None perceptible.			Baggage car (589). Rear platform.	
26	None perceptible.		None perceptible.			“ Deerfield ”. Middle of car.	
27	390	0·08	390	0·02		Baggage car (1107). Three feet from engine.	
28	390	0·04	390	0·02		Baggage car (1107). Middle of car.	
29	390	0·02	None perceptible.			Baggage car (1107). Front of car.	
30	390	0·08	None perceptible.			Baggage car (1107). Three feet from engine.	
31	390	0·02	None perceptible.			Baggage car (1107). Middle of car.	
32	390	0·02	None perceptible.			Baggage car (1107). Middle of car.	8 : 00 p. m.
33	390	0·02	None perceptible.			Buffet car. Rear platform.	
34	None perceptible.		None perceptible.			“ Deerfield ”. Front platform.	
35	388	0·06	388	0·02	St. Paul depot	Baggage car (1107). Three feet from engine.	8 : 35 p. m.

The extent of the vibration is greater in some parts of the car than in others. The minimum vibration seems to be found at the points of support of the car floor — the king bolts. The vertical vibration is nearly always greater than the horizontal vibration, but exceptions to this have been observed. Thus, the maximum vertical displacement shown on the vibration records is 0·05 inch in the Chicago, Milwaukee & St. Paul tests and 0·10 inch in the Chicago & Northwestern tests. The maximum horizontal displacement as shown on the records is 0·02 inch in the Chicago, Milwaukee & St. Paul tests and 0·06 inch in the Chicago & Northwestern tests. This displacement of 0 06 inch, however, is an exceptional case. Since the vibration recorder magnifies the vibration two-fold, the actual vibration is one-half of the amount indicated by the figures. It is quite probable that the real displacement is somewhat greater than this since the friction of the instrument absorbs some of the energy of the vibrations.

The buffers and vestibule plates transmit the vibrations from one car to the other, but as the cars are not rigidly coupled together, the energy of the vibrations is largely lost in the flexible joints. The vibration is greatest in the vicinity of the lighting set and becomes less as the distance from the set increases. In other words, some parts of the train vibrate more than others, the most vibration being found at the front end of the train and least at the rear of the train. The tremblings can be detected in the third and sometimes in the fourth and fifth car from the generating set, depending upon conditions.

The amount of vibration depends upon the manner in which the train comes to a stop. When the train comes to a stop with the buffers and vestibule plates tight together, much vibration is felt in the train, but when the buffers and plates are loose, less vibration can be detected. This is shown when the train comes to a stop on a grade. If the grade is down, the cars press against each other and put the buffers and plates into intimate contact. The result of this condition is that the vibration is quite noticeable. If the grade is up, the cars tend to separate, the buffers and plates are not in close contact and a small amount of vibration is transmitted back into the train.

Similar conditions arise when water is being taken at a station. When the engine is " spotted for a water tank ", it must be brought into position carefully. If the engineer gets the tender too far ahead of the water spout he backs up a trifle, thereby, " bunching " the train and putting the buffers and plates into intimate contact. This condition makes the vibrations strongly perceptible. On the other hand, if the tender stops too far back of the spout, he goes forward a trifle, thus loosening the contacts. A small amount of vibration is then transmitted.

Another point, in this connection, is that as soon as the train comes to a stop, vibrations are felt. But, in starting up again, as soon as there is a pull on the drawbar and before the locomotive driver wheels have made a quarter turn, the vibration disappears. At the instant of starting the buffers are pulled apart so that the vibrations are not readily transmitted.

The weight of the train, the weight of the cars, and the weight of the load have an effect on the magnitude of the vibrations. This is apparent, since it takes more energy to shake a heavy load than it does to shake a light one. Having given an engine set the impulses of which produce vibrations of a certain magnitude on light cars, it is probably safe to assume that the same engine will produce vibrations of smaller size on heavier cars.

The size of the reciprocating unit enters into the question. The moving parts of a large unit, being larger, will produce greater disturbing forces, and, for a given weight of car, will produce larger vibrations than a smaller unit. For instance, the records in this paper show that the vibrations can be detected as far back as the third car from the locomotive for 20 kilowatt Westinghouse sets. In February, 1906, while the train was standing in the Chicago, Milwaukee

& St. Paul depot at Minneapolis, the vibration was barely perceptible without instrumental means in the fifth car from the locomotive, a 25 kilowatt, Westinghouse set being in use at this time.

The records plainly show that the trains equipped with turbine lighting sets are exempt from the annoying vibrations which are likely to traverse a train from a reciprocating engine set.

Aside from the vibratory effect of these lighting sets, noises are produced which are annoying at times. With the Westinghouse set, when the steam pressure is low, a knocking or pounding of the engine takes place when under load. This noise is transmitted back into the train for a considerable distance. The speed (400 revolutions per minute) is low enough so that each separate knock can be heard. With the turbine set, a humming or buzzing sound is observed. The higher speed of the turbine (3,600 revolutions per minute) makes a noise characteristic of high speeds.

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II. — DISCUSSION.

Mr. W. L. Abbott (M. W. S. E.), chairman. — One thing that impressed me while listening to the paper is that passengers on a train are not discommoded nor annoyed by the tossing and pitching of the train, incident to traveling over rough roads and around curves, but the instant that the train stops they detect at once a slight tremor, in amplitude, as I understand from the paper, of $^1/_{32}$ inch. It is possible that when the train is moving, the vibrations might be as great as 3 inches in an extreme case, without being particularly disturbing Possibly this is because those vibrations are not regular, and for that reason are not noticed to any extent, but when the train comes to rest, and all other motions cease, the vibrations continue in an isochronous manner, some 400 vibrations a minute and only $^1/_{32}$ inch in an extreme case; it is very noticeable and annoying. It occurred to me that if these electric lighting engines were set with the crank shaft crosswise of the car — and some of them appear to be so — the vibrations transmitted to the train would be lengthwise and would consist in tightening and slackening the draw-bar spring, and I would expect that it would not be transmitted at all, and if at all, very little. In that case (if that were true) I would suppose they would set their engines that way.

However, the advent of the steam turbine has relieved the situation entirely, as a turbine is better adapted for such work than a reciprocating engine. . I presume that that is the prime mover which is being installed now on such trains.

The subject of this paper is one of interest to those who are concerned in the refinements of first class train service, which requires the removal of all possible annoyances which might disturb the high priced passengers in the Pullman cars. I notice that those who ride in the smoking car get the greatest shaking up, and therefore it is not as bad as though they had the baggage car in the midst of the sleeping cars.

Mr. J. H. Warder (M. W. S. E.). — What fixed the element of the weights you used that by their inertia give the vibration to those pointers, which were recorded on the paper? Was there any particular determination as to what those weights should be?

Mr. Huels. — That weight was not pre-determined. The weights used in the machine were tried and found to do what was required.

Mr. Warder. — What is that metallic paper? Is it the same as is used with steam indicators, with a smooth coated surface?

Mr. Huels. — Yes, the same thing; it has a very smooth surface on one side, and you can make a mark on it with a metallic point such as silver or brass. The reason we use a metal point is, it does not break off or wear out as rapidly as other kinds.

Mr. E. C. De Wolfe (M. W. S. E.). — We used to have to pay high prices for that metallic paper. I recently discovered that it is nothing more than a good quality of glazed paper such as is used in a fine catalogue, and can be had from the paper dealer at much cheaper rates than formerly.

With regard to those vibrations, Mr. Abbott spoke about the generating set being placed crosswise, as in the St. Paul practice, throwing a longitudinal vibration. I was wondering whether the instrument was set the same way for both systems; that is, in the Northwestern test, was the instrument set to read a transverse vibration on account of the generating set having its axis lengthwise of the train, and in the St. Paul set the other way?

Mr. Huels. — The object was to get comparative results; the instrument was set up the same way on both trains.

I always observed one way of setting the recording instrument in relation to the length of the car, whatever might be the method of placing the generating set in the baggage car. The horizontal motion was lengthwise of the train.

Mr. Abbott. — Is that the objectionable motion?

Mr. Huels. — No, the objectionable motion is up and down.

Mr. Abbott. — Is the crosswise motion objectionable?

Mr. Huels. — There is very slight vibration from the crosswise motion. I found, after making a few observations, that what we call a crosswise movement of the train was so small I could not record it, and I paid no attention to it after that, simply taking the vertical vibration and horizontal vibration in the longitudinal direction of the train.

Mr. E. P. Marsh. — The matter of vibrations on passenger trains was something which developed after the idea of furnishing electric light on trains was suggested, and on some roads an endeavor to minimize the vibration was attempted by using a special spring draw-bar carrier yoke, as the vertical vibration is transmitted chiefly through the draw-bar pull, and by use of this spring yoke, it was endeavored to remedy at least a part of this vibration. The choice of position of the various sets sometimes varies for different reasons than have been suggested by the author. For instance, on the Northwestern road, the chief reason for carrying the outfit on the rear end of the car is that the outfits are quite valuable; in case an accident occurs, and the tender comes back through the baggage car, if the outfit is at the forward end of the car the outfit is lost; if on the rear end, it is more likely to be saved.

Mr. Huels. — I was wondering why the Northwestern road thought more of its generating sets than the comfort of the passengers. The St. Paul road sets its machines in a reverse position to that of the Northwestern road.

Mr. Marsh. — The Northwestern road has lost one outfit just that way. On new equipments, however, the turbine type is used exclusively, and a large number of axle light outfits are being applied, which have given no trouble in the way of vibration.

Mr. W. E. Symons. — I have been much interested in this very valuable and interesting paper of Mr. Huels', as it has brought to my mind a number of points in connection with train lighting, and vibrations, some of which I had reviewed some years ago; others have been made clear to me, that had not occurred to me before.

Some eight years ago, I was in charge of the mechanical department of a system of railways in the south, and was located at Savannah, Ga. We participated in the operation of what was called the *Florida Limited Train* from New York City to St. Augustine and Port Tampa, and handled by the Pennsylvania Railway; Richmond, Fredericksburg and Potomac Railway, the Atlantic Coast Line and the Plant System, the Plant System having the majority of the mileage. Of course, it fell to us to stand the greater part of the responsibility and expense. Electric lighting was introduced about that time pretty generally on through trains, and the question of the vibrations, described and analyzed in Mr. Huels' paper, came up. At first it seemed, from the reports we had, that it was something serious; the complaints coming principally from people of wealth and refinement who lived in luxury, and were accustomed to having things made comfortable for them; therefore, the vibrations of the train annoyed them a great deal, and while I was not prepared to conduct any such series of tests, as described by Mr. Huels, yet I made some practical tests in the way of taking actual measurements of the movements of the car body when standing still, with the lighting equipment in movement or operation by placing some fixed gauges in contact with the car, and then measuring the vibrations that actually occurred. I discovered, as a result of these observations, that the vibrations were practically as outlined in Mr. Huels' paper, possibly a little greater. The movement was about $^1/_{16}$ inch. That average was taken from a combination baggage and express car, with the lighting equipment in the front extreme corner, not over the king pin, and not in the center of the car; therefore, it gave the car what might be called a tilting motion in addition to the regular vibrations, that came from the equipment itself, and that was transmitted back through the train quite perceptibly. But in following my tests through the cars, that were attached to this head car, I discovered that the actual movement of the car became almost nil, but the noise was very pronounced. The proposition therefore resolved itself into this, that while there was a noticeable, and to some, a disagreeable *noise,* the vibrations were too slight to have caused any real discomfort; as a rule, the passengers were not disturbed as much as they really imagined they were.

Sometimes in hotels or large buildings, very perceptible vibrations are observed, and one might think that the building was in danger, when in reality it is frequently caused by vibrations from some light, high speed machinery fastened to, or in some manner connected to the walls. In connection with the train investigations and as an experiment, I took one car and moved the equipment to the center of it, and found that the vibrations were very much reduced. Following that, I changed the foundation arrangement, setting the engine bed on a number of helical or spiral springs, placing a yoke over the engine bed and fastening to the car floor, so that in train movement there would be no danger of the engine being thrown from its position. When the equipment was in service under these conditions, there were scarcely any vibrations whatever; they were almost entirely eliminated, although the noise was just as perceptible in the rear car, as when bolted to the car floor. Some of the passengers who complained of the noise did not know the difference.

Investigation of vibrations in a brick building, where the walls seemed to be effected as shown by the mortar crumbling and working out in the form of dust, I assumed that the mortar was not of the best quality; the vibrations were so pronounced as to interfere with desk work in the building.

I went into the basement, and found a little high speed electric light engine fastened to a concrete floor, which was connected to the building walls, thus forming a perfect conductor, and transmitting these vibrations through the walls, and which were in places gradually undergoing a process of deterioration; in my opinion, in time this would have affected the safety of the building. In connection with this, I recommended that they apply the same remedy, which gave such good results with train vibration; they did so, and after that, one could hardly discover there was any machinery working in the building, so far as vibrations were concerned.

There is another point, that I wish to mention in connection with train vibrations, and that is, if the author of this paper would carry this matter still further, to the extent of taking a record of the vibrations of both passenger and freight trains in movement, due to the component of undulating or imperfect roadway and speed, it would be very valuable to railway companies; it would determine, to a great extent, the cause of many derailments and accidents that are now simply passed by as "cause unknown".

This is a subject that has not infrequently been broached to railway managers. Some are favorable to its introduction; others again, I presume, may think it might reveal certain track conditions which they do not want made known.

In my opinion, some tests as these would be very valuable in connection with railway operation, as the subject seems to present a broad and inviting field of practical experiment with some scientific research.

Mr. Huels. — The reason I made these experiments, is because a number of students at the University of Wisconsin were testing some of these lighting sets; we tried to make some kind of a comparison between the different outfits to find out which would be the better for any given condition. We tested for steam economy and found that the turbine sets take a great deal more steam than the Westinghouse sets. So I thought it would be very interesting and possibly afford some means of comparison to get vibrating observations graphically. You have the turbine, taking more steam but having no vibration and hardly any noise, and there are these high speed vertical reciprocating engines, taking less steam and giving more vibration; when the steam pressure is low, there is considerable noise. There are other factors that come in, in choosing a lighting set besides vibrations and steam economy. As you all know, the steam turbine does not require any cylinder oil. I do not mean in the bearings, but inside of the moving parts no oil is required, and of course that is a factor in the economy of operation.

With regard to Mr. Symons' suggestion, that the matter of tests be carried further, "to the extent of taking a record of the vibrations of both passenger and freight trains in movement, due to the component of undulating or imperfect roadway and speed", and in that way determine irregularity of roadbed, I have looked into this matter to some extent, and came across some articles on tests of this kind. I noticed that the results of these tests were not altogether satisfactory when made on English railways. I found no record of such tests made on American railways.

My machine was built to measure these very small vibrations — not more than 0·10 inch from the record — while the vibration of a car body is so much greater than that, it shakes my machine all to pieces. I have some blue prints showing what it did with this machine on roadbed. They are not perfect records by any means, and perhaps not accurate.

I have some records of a car coming to a stop at a railway station and starting up again, showing the effect of braking. I regret that I have not more time to work up such tests as these, but am sure those roadbed tests would bring out many points of interest.

The article on tests made in England (referred to) brought out the fact that in passing over a certain piece of roadbed, a peculiar shaking appeared on the record. The railway people went out and inspected the roadbed but could find nothing the matter with it; then they started digging, and found that the ties were all rotten; they could put a pick right through them; although in looking at them from the outside, the top appeared to be in good shape. A good many things could be brought out on the records taken on the run of a train. One of those machines could be put in a car and locked up, and in that way an automatic record could be gotten of the whole trip; you could tell when an engineer started the train and when he stopped;

if the train was late — why? A new record could be put in for every trip. In this way, one could tell a good deal about the operation of the road. It seems to me that information of that kind would be very valuable.

Mr. Warder. — Do you see any difficulty in modifying your machine so that it would be suitable to carry out the idea of Mr. Symons, to record the condition of the track, etc.?

Mr. Huels. — Perhaps this particular machine could not be modified, but I think such a machine could be made. I have some references to some articles in different engineering periodicals on machines actually used for that purpose, although I am not able to judge just what a railway operating man would want.

Mr. Symons. — In making practical tests for the purpose of determining the flange resistance of car wheels against the rails when rounding curves due entirely to the curvature, a plan has been found at times reasonably accurate, wherein pieces of pig lead are placed on either side of the draw-bar shank of sufficient dimensions to fill the space between the draw-bar shank and the filler block on either side; this while the cars are standing on a tangent and properly coupled. The train is then pulled around a curve of a certain known degree of curvature, which, of course, results in the pieces of lead being mashed, or flattened in proportion to the amount of pressure against them; after rounding the curve, and coming on to a tangent, or straight track, these pieces of lead are removed, taken to the laboratory, where similar sized pieces, or duplicates, are subjected to pressure in a hydraulic machine with a recording gauge, and when they have been compressed or reduced, the same as the pieces removed from the car, the gauge will indicate a pressure equal to that of the wheel flanges against the rail when the cars were rounding curves; we can, by this method, figure very closely as to the extent of pressure resulting from curvature, and learn much as to the cause and effect of flange wear, rail wear, spreading of rails, and other features in connection with the design, construction, and maintenance of car wheels, trucks and rails on which they run. This method would not clearly indicate the cause of derailments, or the breaking of flanges on car wheels, for the reason, that it does not include the component of all the forces resulting from curvature, speed, centrifugal force, rolling of cars due to rough or undulating track, etc., which all have more or less bearing on the question. It very clearly indicates the pressure against the outer rail when rounding a curve at a slow rate of speed, and it also serves as a guide whereby the engineer, or car builder, can determine what is a sufficient amount of flexibility to be allowed or provided for with cars of certain lengths for rounding curves of a certain degree of curvature.

Some kind of a machine built on pretty much the same lines as the one used in the vibration tests described here this evening, but on a much larger scale; that would show the component of all those forces which I have outlined as applying to cars when rounding curves would be of great value. Some of our modern freight cars weigh when empty 46,000 lb., or twenty-three (23) tons, and when loaded have a total weight of 156,000 lb.: these are sometimes hauled at a speed of 40 to 50 miles per hour, and under certain track conditions, they possess a rolling, or swaying motion; the effect of which, at the present time, we have no means of measuring; we know, as a fact, that it is something terrific in its effect both on the equipment and on the track. Sudden lateral thrusts break a car wheel flange; possibly it is a component of velocity together with weight of car and contents. At times, this fracture may be assisted by the flange being somewhat worn, and imperfect roadway would also contribute to the same result. Some machine, that will accurately measure and record the motion of cars under these conditions, and at the same time indicate at what particular place on the line of road the readings were taken, so that an accurate description of the track at that point could be added, would be a great benefit. It would possibly indicate by its application to different kinds of cars (and at different speeds), for instance, refrigerator cars, loaded or empty, furniture cars, coal cars, box cars and others, that speed which might be considered a *safe* rate for one class of these cars, would be *absolutely dangerous* for others.

Following the wreck of a railway train, the different departments involved, as a rule, are called upon to explain why, particularly when the cause of the wreck may have been assigned to a defect, or a condition chargeable to any particular department. Generally each department, including the mechanical, transportation and maintenance of way, attempt to show, or explain, that the real difficulty rests with the other fellow, and is usually able to make rather a strong case from his own point of view; as there are usually many broken wheels, bent axles and bady damaged trucks in a wreck, it is difficult to reach a conclusion as to whether some of them *caused* the accident, or were the result of it, and if a series of tests could be conducted with some machine, as I have previously suggested, that would give some clear, comprehensive ideas of the behavior of cars of different types, and under the different conditions mentioned. When running and at the same time taking note of the track condition, or in some manner indicating the point where the readings were taken, it would furnish excellent means for not only checking up track conditions, but it would also indicate what classes of cars are best suited for certain speeds. I am quite sure the results would not only be very interesting, bnt useful, valuable and welcome information to the railway managements.

Mr. Huels. — At the University, we have a lot of students who have to write a thesis before they graduate, and I am sure, if the railway companies and men like Mr. Symons, who have these problems to work out, would give us a list of them, we might be able to put some of the students to work on them, and perhaps get some results that would be of value.

There is one point that comes up in connection with these two kinds of train lighting sets that seems to be of considerable interest. It was suggested to me by Mr. A. J. Farrelly, electrical engineer of the Chicago & Northwestern Railway. It is the factor you might call the gyroscopic action of those lighting sets. Take a bicycle wheel and hold one end of the shaft in each hand; if the bicycle wheel is at rest you can change the plane of the wheel very readily; but if the wheel is set to spinning rapidly and if you now try to change the plane of the wheel, there is a resisting pressure on your hand. I do not know just what the resisting pressure is, but the greater the number of revolutions per minute, the greater is the resistance pressure on your hand. You can imagine that same thing taking place in a lighting set. Take a Westinghouse set, running at 400 revolutions per minute; there is a certain gyroscopic action there. Take the Curtis turbine, running at 3,600 revolutions; there is certainly a greater gyroscopic action there. The De Laval Steam Turbine Company also puts out a lighting set, and in their small sizes the sets run at 10,000 to 30,000 revolutions per minute. There certainly must be a still greater gyroscopic action in a De Laval set. In addition to that the Westinghouse people have a shaft 5 or 6 inches in diameter — not smaller. The General Electric Company has a shaft about that size, while in the De Laval turbine the shaft is as small as 1 inch or less, and is made flexible on purpose. The way that factor comes in is in this way: take your equipment — say the De Laval — and set it lengthwise of the car; your train is going 40 miles an hour; suddenly it comes to a bend in the road, which turns the set around suddenly. The question is, is that bend great enough to spring that shaft so it will break? Another point is, is the effect of that gyroscopic action greater when the lighting set is placed lengthwise of the car, so that the shaft is parallel to the axis of the train, or greater when the lighting set is placed cross-wise? You sometimes hear of a train lighting set coming in with a broken crank shaft, and I have heard of a Curtis turbine falling to pieces and damaging the cab. You might look for some danger to the bearings breaking, due to this gyroscopic action. That is a question we do not know anything about. The people who put out those engines say, " Well, we have sets that are running all right. " But it is a problem that it would be well to look into.

Mr. F. C. Harper. — Mr. Symons mentions the fact of flange breakage. I know of a case on construction track, where there was an excess of flange breaking. The track was in poor condition, as is usual on such work, and the tonnage extremely heavy. The flange breaking caused a number of wrecks and was such a serious detriment in the operation of work trains, causing directly and indirectly an item of expense so entirely out of proportion, that the railroad company sent an expert down to look at the wheel flanges, examining them rather than the track which caused the trouble. It occurs to me that possibly if they had examined the track more closely they would have been able to quickly locate the cause of the trouble. It would have been economy in the construction of the track to have spent more money for ballast, etc., enabling a better track to have been equipped, and incidentally at a less expense for maintenance and broken wheel flanges.

[625 .253]

RECENT DEVELOPMENTS IN AIR BRAKE CONTROL APPARATUS,

By F. H. PARKE and S. W. DUDLEY.

Figs. 1 to 24, pp. 1009 to 1024.

(*Railroad Gazette.*)

The two most important factors in originating and directing the course of the recent rapid developments and fundamental changes in the control apparatus of the air brake have been, first, the broadening of the field of its application to include electrically operated railways, and, second, the enormous growth in rolling stock of all kinds, and consequent increase in the requirements of train operation.

As recently as three years ago, the various standard types of air-brakes, which had then for some time been in use, were deemed ample to meet all possible operating demands. But the increasing requirements of surface traction, which was rapidly passing from almost universal single car operation to that of trains, made it desirable to substitute an automatic brake for the straight-air systems then in general use, which would combine to the highest possible degree the safety of the automatic brake and the flexibility of operation of the simple straight-air control.

The automatic air brakes.

Before proceeding further, it may be well to describe biefly the principle governing the automatic brake : Each vehicle has a pipe, called the brake pipe, running its entire length, with hose couplings on each end for connection to adjacent vehicles; also an auxiliary reservoir, in which is stored the air supply for use in operating the brakes on that vehicle; a brake cylinder with piston and rod, the latter connected to the brake shoes through suitable rods, levers and brake beams; a triple valve which forms the connection between a branch from the brake pipe, the auxiliary reservoir, and the brake cylinder, in such a way as to 1° charge the auxiliary reservoir by connecting it to the brake pipe; 2° apply the brakes by connecting the auxiliary reservoir to the brake cylinder, and 3° release the brakes by connecting the brake cylinder with the atmosphere. The principal element of the triple valve is a piston, the rod of which moves a controlling slide valve. Brake-pipe pressure is always present on one side of this piston, and auxiliary-reservoir pressure on the other, so that the operation of this valve, and therefore of the brakes, depends on the difference between these two pressures. As the brake pipe extends through the entire train, a means is thus provided for operating the brakes on each car from the leading vehicle, namely, by altering the brake-pipe pressure. It is lowered to apply the brakes and increased to release them, thereby embodying the essential feature of an automatic brake, because, if any rupture occurs in the brake pipe or its hose connections, the pressure is at once reduced and the brakes are automatically applied.

The straight-air brake.

The straight-air brake, on the other hand, has no auxiliary reservoir nor triple valve. It has no supply stored on each car, nor any pressure in the brake pipe when the brakes are not applied. It depends on the supply stored in a single reservoir on the leading vehicle, which is admitted through the brake pipe directly to the brake cylinders to apply the brakes, and released from the pipe and cylinders to release the brakes. This, of course, means no braking power if any part of the piping system is ruptured even in single car operation, but a very accurate means of controlling the cylinder pressure (in short trains) both in applying and releasing, thereby constituting the feature of flexibility.

The prominent operating feature of the straight-air brake system, which contributes largely to its flexibility, and which until lately has been lacking in the automatic system, is the ability to release the brakes gradually. This enables the operator to approach the stopping point at a high rate of speed and apply the brakes with full power. Then, as the speed is reduced, he is able to accommodate the retarding force to the decreasing amount of energy to be overcome and the increasing coefficient of friction, by reducing the brake-cylinder pressure in a series of steps or graduations. Therefore, at all times, during the stop, there is being exerted a retarding effort, which is the maximum permissible at that particular instant, consistent with smooth handling and the absence of wheel sliding. Furthermore, this ability to control the release of the brake-cylinder pressure enables the stop to be made with the greatest possible accuracy. These features of operation are essential in a service where fast schedules and frequent stops are required. However, when train operation is introduced, not only is the flexibility of the straight-air system seriously interfered with, but the consideration of safety becomes of prime importance. Any parting of the train or rupture in the hose or piping connections, would result in instant and total loss of braking power, and this would be most likely to occur just when full retarding power was most needed.

As the automatic-brake system was primarily designed to meet this contingency and prevent the possibility of such a loss of braking power, it was evident that the time had come when it was necessary to evolve a system which would combine the flexibility of the straight-air with the safety of the automatic system. It was, therefore, manifest that such a new system must, whatever else was included, have as its fundamental characteristic, the automatic feature. This meant that the automatic brake, as then known, would have to be modified so as to include the principal features of flexibility characteristic of the straight-air systems, *viz.* : the graduated release, and the ability to make brake applications in rapid succession. This latter feature depends on the rapidity with which the auxiliary reservoirs can be recharged, after an application and release are made. Consequently the two necessary features to be incorporated in the old automatic brake were the graduated release and quick recharging of the auxiliary reservoirs. This meant a modification in the triple valve to include the points mentioned in addition to the functions which it already performed.

Graduated release.

Considering first the means adopted to secure a graduated release : The operation of the triple valve is governed by the difference in brake pipe and auxiliary reservoir pressures, acting on the opposite sides of the triple valve piston. To apply the brakes, a reduction in brake-pipe pressure is made, which leaves a higher pressure on the auxiliary reservoir side. The piston is consequently forced toward the lower pressure, carrying with it the attached slide valve, which in its movement opens communication between the auxiliary reservoir and brake cylinder. This causes the pressure in the reservoir to be reduced, by the flow of air to the brake cylinder, until it has fallen to slightly below that remaining in the brake pipe. The pressure on the brake pipe side of the piston being now slightly in excess, the piston and slide valve are moved back sufficiently to prevent further change of pressure.

In order to release the brakes, when thus applied, an increase in brake pipe pressure is necessary. This will force the piston and slide valve back to its normal or release position, allowing the brake cylinder pressure to escape to the atmosphere, and at the same time recharging the auxiliary reservoir. This would continue until the brakes were wholly released, and the reservoirs fully recharged, unless in some way the triple valve piston could be moved back from the release position to cut off the exhaust of brake cylinder pressure, and the flow of air to the auxiliary reservoir. This was impossible with the old standard types of triple valves, as the pressure in the auxiliary reservoir was dependent upon the air supplied to it from the brake pipe only, and, therefore, manifestly it could never exceed the brake pipe pressure during the release, or move the piston and slide valve from release position. But suppose that a reserve supply of air at maximum brake-pipe pressure is so connected to the triple valve that it can flow to the auxiliary reservoir only when the triple valve piston is in release position, and suppose that after an application, only a part of the reduction is restored to the brake pipe. The triple-valve piston goes to release position, as before, but the connection then made with the reserve supply allows air to flow to the auxiliary reservoir, thus helping to recharge it. If allowed to continue, this would raise the auxiliary-reservoir pressure to that of the reserved supply. But this does not occur, since when the pressure in the auxiliary reservoir slightly exceeds that now in the brake pipe, the triple valve piston is caused to move back from the release position sufficient to cut off both the brake cylinder exhaust and the connection to the reserve supply. In this way, partial releases may be made until the brake cylinder is entirely exhausted.

The method employed in working out the above in the actual triple valve, is illustrated in figures 1 to 3, 5 and 7 to 10. These views, it must be borne in mind, are purely diagrammatic, bearing no relation to the actual construction of the valve, but showing all the ports and passages in one plane and connected in the simplest possible manner. The different connections to the triple valve are as follows :

Brake pipe at *a*, brake cylinder at *c*, the reserve supply at *x*, while *p* is the exhaust connection to the atmosphere, and R is always in communication with the auxiliary reservoir.

It is clear from the illustrations that, as in the standard types of triple valves, the triple valve piston has brake pipe pressure on one side, namely, in chamber *h*, and auxiliary reservoir pressure on the other, namely, chamber R.

Suppose the brakes to have been applied by a 15-pound reduction in brake-pipe pressure, and assume the initial pressure to have been 70 pounds. As soon as the pressure in the auxiliary reservoir has fallen slightly more than 15 pounds, the valve will be returned to service lap position shown in figure 2. There is now 55 pounds in the brake-pipe and auxiliary reservoir, while 70 pounds is still available in the reserve supply and port *x*. Suppose now the brake-pipe pressure be increased 5 pounds. The piston and slide valves will be returned to release position, as shown in figure 1, in which position the auxiliary reservoir is being recharged from two different sources, through three different channels. Air from the brake pipe passes through the feed groove *i*, as usual, and also, lifting the check valve, through passage *y*, in the valve body, *j*, in the main slide valve, and *u* in the graduating slide valve to the chamber R. At the same time, air from the 70-pound reserve supply feeds into chamber R through ports *x* in the valve body and *k* in the main slide valve. By this means, the auxiliary reservoir pressure is increased until it has reached slightly more than 60 pounds, when this increased pressure on the reservoir side of the piston over that on the brake-pipe side, causes the piston and graduating valve only to move to the left until the piston stem strikes against the slide valve. This movement closes ports *k*, *j*, and the brake cylinder exhaust port *r*, thus preventing further escape of air from the brake cylinder. This position, known as release lap, is illustrated in figure 3.

If the brake-pipe pressure is raised 5 pounds more (to 65 pounds), the operation described above will be repeated, allowing a further portion of the air remaining in the brake cylinder to escape. This operation may be repeated, thus exhausting the cylinder, and recharging the auxiliary reservoir in a series of steps, until the brake is fully released and the auxiliary reservoir fully recharged. Thus a simple and adequate means is provided for graduating the release of the brakes, positive in its action and sensitive enough to meet all the requirements of service.

Quick recharging.

In the graduated release operation, the auxiliary reservoir is being recharged through three differents ports, instead of one (the feed groove *i*) as formerly, and in such a manner that the rise in auxiliary reservoir pressure is proportional to the fall in cylinder pressure, so that when the release of the brake is complete, the auxiliary reservoir is practically fully recharged and ready for an immediate reapplication if necessary. Having these features incorporated in the automatic system, the flexibility of straight-air operation is closely approximated without in any way impairing the safety features of the automatic control. In fact, a distinct advantage from the standpoint of safety is gained by the quick recharge feature, which insures, at all times, the possibility of full braking power being developed, without regard to the length of time intervening after a release — a condition not even approximated by either the straight air or former automatic systems.

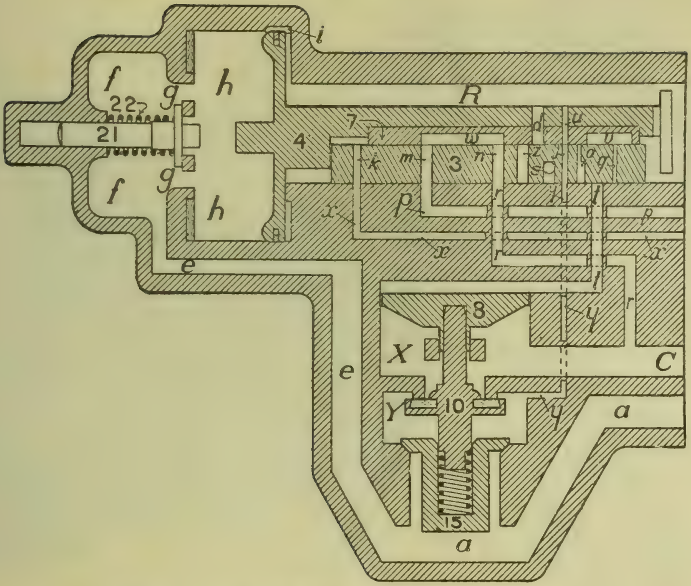

Fig. 1. — Type R triple valve; release position.

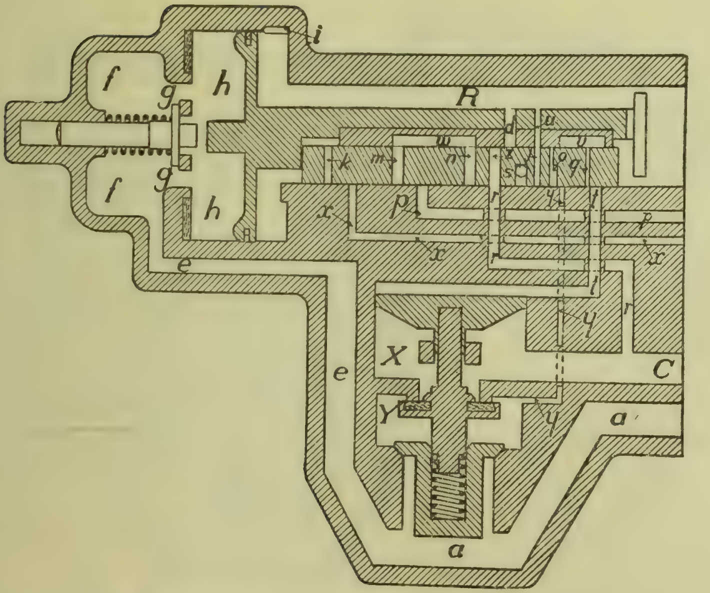

Fig. 2. — Type R triple valve; service lap position.

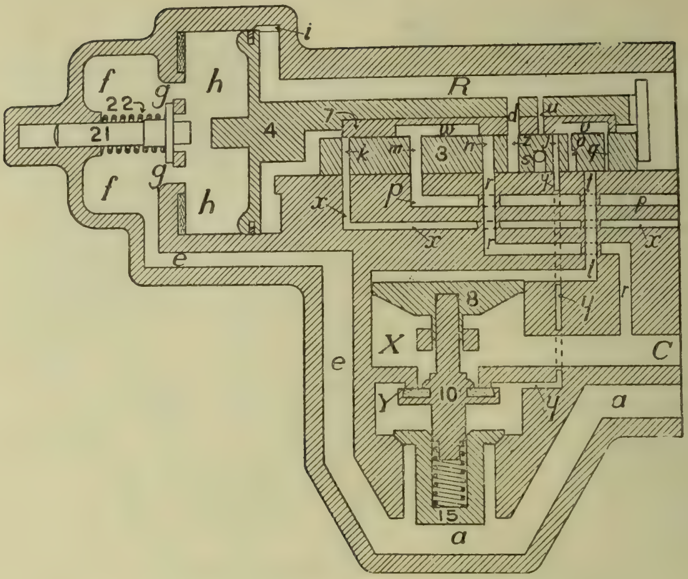

Fig. 3. — Type R triple valve; release lap position.

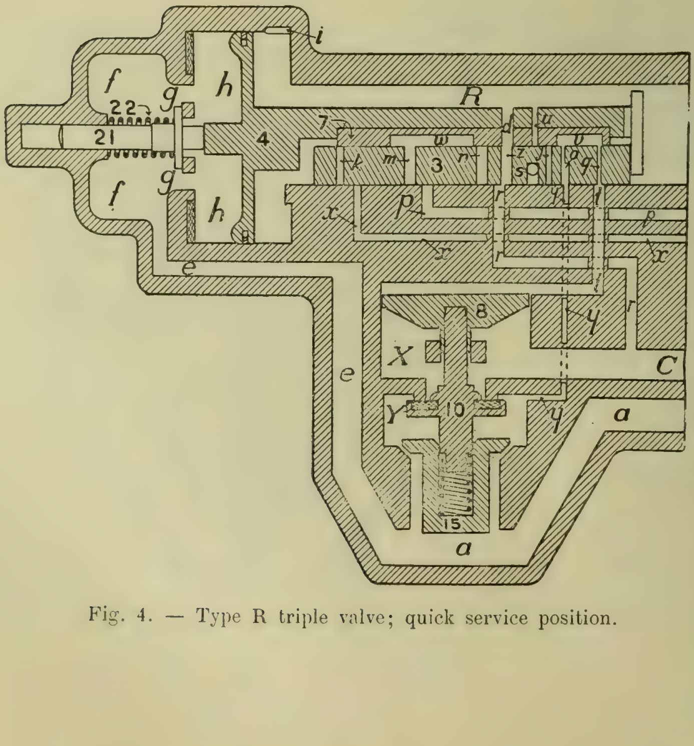

Fig. 4. — Type R triple valve; quick service position.

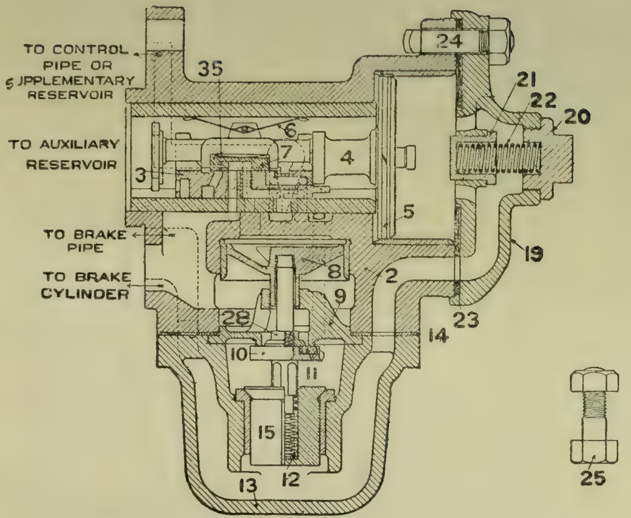

Fig. 5. — Section through type R triple valve.

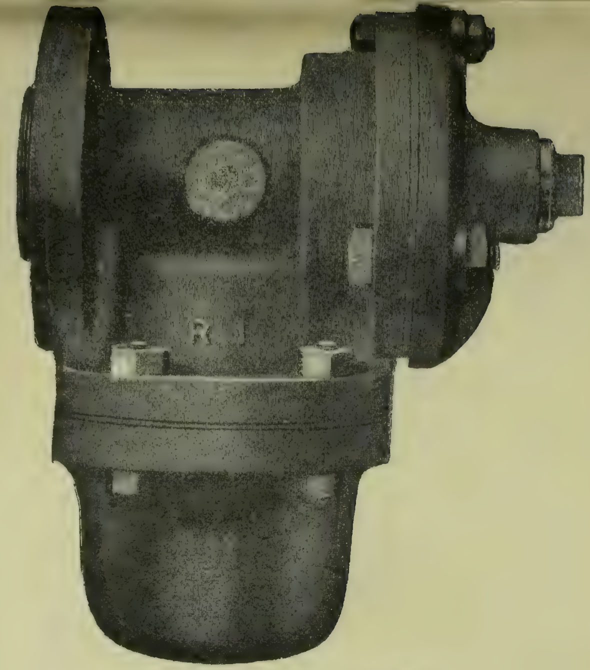

Fig. 6. — Type R triple valve.

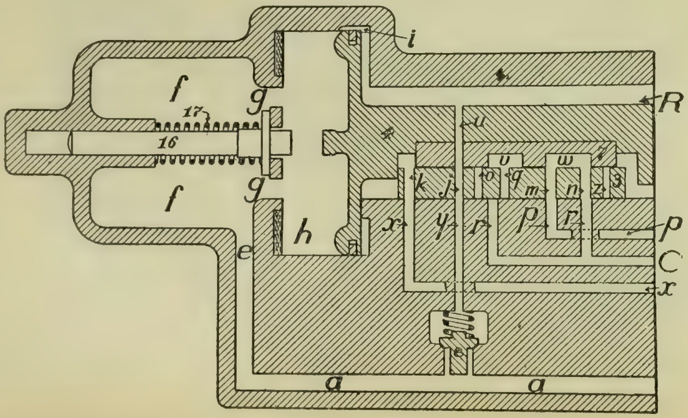

Fig. 7. — Type T triple valve; release position.

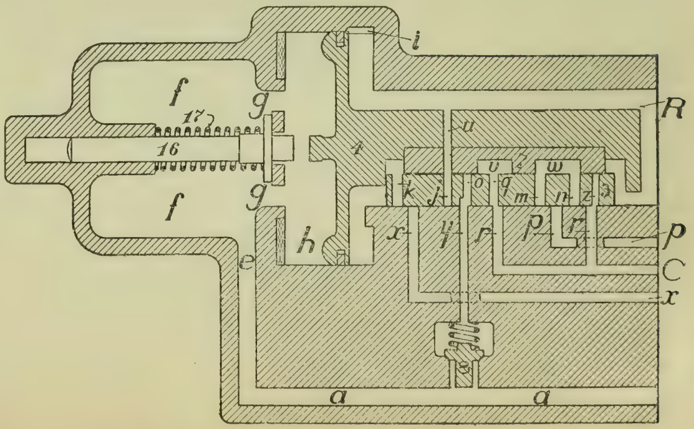

Fig. 8. — Type T triple valve; release lap position.

Triple valves for single cars.

The quick action features of a triple valve consist of the check valve 15, rubber-seated valve 10 and piston 8, shown in figures 1 to 3, 5 and 7 to 10. In an emergency application, auxiliary-reservoir pressure is admitted above piston 8, which causes it to unseat valve 10, and allow air from the brake pipe to raise check valve 15 and flow rapidly to the brake cylinder through chambers Y and X until the brake cylinder and brake-pipe pressures become equalized. The check valve then seats and prevents cylinder pressure from flowing back to the brake pipe. This is the means employed for hastening the brake-pipe reduction throughout the train, as each triple valve vents a portion of the brake-pipe air to its cylinder, which similarly affects the triple valve on the next vehicle, and so on through the train. It also raises somewhat the cylinder pressure obtained, due to the air introduced from the brake pipe. If the brake-pipe reduction is considerably more rapid than the reduction in auxiliary reservoir pressure due to its flow of air to the brake cylinder, the triple-valve piston will assume the emergency position, which will result almost instantly in an application with maximum braking power.

Although the features of graduated release and quick recharging were originally developed in connection with the quick-action triple valve, they can just as readily be incorporated in the plain type of triple valve; that is, one without the quick-action features. This was the next step taken.

Plain triple valve with graduated release and quick recharge.

The first form of plain triple valve to be designed to embody the features of graduated release and quick recharge of auxiliary reservoir was for train operation limited to two cars. With this valve, the graduated release feature was obtained by piping the exhaust of the triple valve to the brake valve, where the air contained in the brake cylinder would either be retained or allowed to escape to the atmosphere at the will of the motorman. The quick recharging feature was obtained in this valve by means of a small check valve which allowed the brake pipe air to flow directly to the auxiliary reservoir when the triple piston was in release position. A further detailed description of this valve will be unnecessary, as all of its features are embodied in the plain triple valve which followed it, which was designed for use on cars to be operated singly or in trains up to five units. This valve, designated as the type T triple valve, is shown in figures 7, 8 and 9.

In figure 7, port *a* connects with the brake pipe, port *x* with the reserve supply, port *c* to the brake cylinder, and *p* to the exhaust through the brake valve, while R is in connection with the auxiliary reservoir.

Quick recharging is obtained partly through the small check valve shown, which connects *a* through ports *y*, *j* and *u* with the auxiliary reservoir, and partly through ports *x* and *k* from the reserve supply. The graduated release of the brakes is obtained in exactly the same way as previously described for the quick-action triple valve, as will be evident at once from figures 8 and 9, the ports being lettered identically. One feature in connection with this valve, however, deserves particular notice. The exhaust port *p* being connected by piping to the brake valve, combined with the use of the reserve supply as previously described, affords two means by which a graduated release of the brakes in the train may be made. The method of graduating the release by means of the reserve supply, in the manner already explained, gives a graduated release on all the cars in the train, while the second method enables the operator to govern the release of the brakes on the head car alone, directly at the brake valve. This latter method makes possible a very flexible control when operating as a single car, and is known as the straight-air release feature.

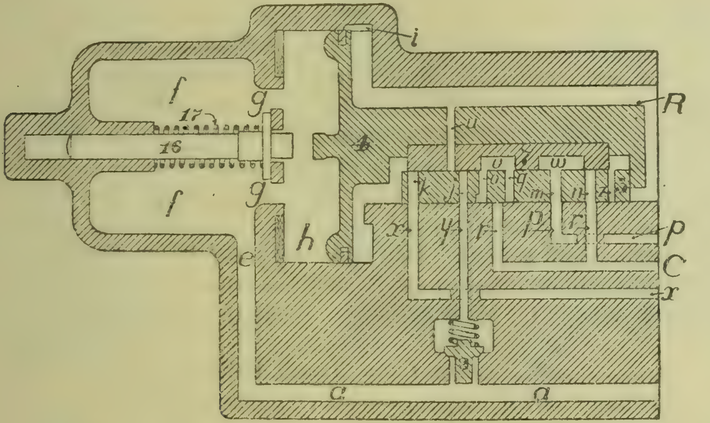

Fig. 9. — Type T triple valve; release lap position.

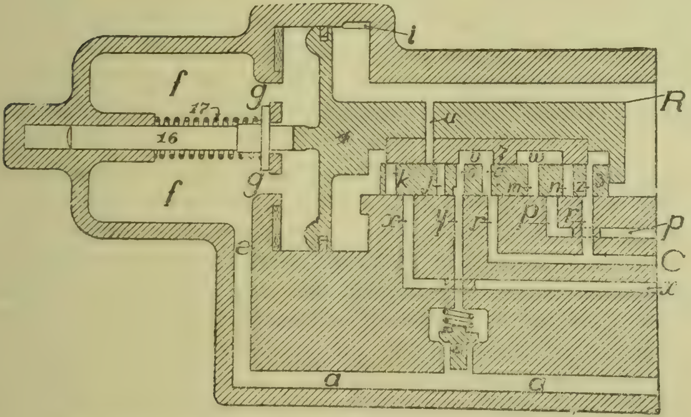

Fig. 10. — Type T triple valve; quick service position.

The application of these valves to trains up to five cars in a service, in which frequent stops from a fast schedule were required, made clear the desirability of a more rapid service application of the brakes throughout the train. The modifications already made in the triple valves, to obtain the quick recharge feature, were easily adapted to produce a quicker service application of the brakes than had previously been possible where the brake-pipe reduction was dependent upon the air contained in the pipe flowing the whole length of the train to the brake valve, before it could escape to the atmosphere.

In emergencies, a rapid serial application of the brakes is obtained by venting a portion of the brake-pipe air to the brake cylinder on each car. This affords a means of escape for the brake pipe air, without all of it having to flow the length of the train to the brake valve. This same method suggested itself for quickening the service application, the action being of the same character as that in emergency, but to a less degree. As there was already a port connecting the brake pipe to the slide valve seat, which in release position affords a means of securing a quick recharge, it was only necessary to add ports to the slide valve, which, in the movement to service position, connect the brake pipe through these ports tot he brake cylinder. In this manner, a slight reduction in brake-pipe pressure is effected during a service application by each triple valve in turn. By this means, the time required to apply the brakes in service is materially reduced.

In figure 7, the additional ports just mentioned are marked *o*, *v* and *q*. In the quick service position, port *o* registers with port *y* (*see* figure 10), and cavity *v* in the graduating valve connects ports *o* and *q* in the main slide valve, the latter registering with port *r*, leading to the brake cylinder, thus establishing direct communication from the brake pipe through the check valve to the brake cylinder. When the piston returns to lap position, figure 8, the quick service ports *o* and *q* are blanked by the graduating valve. This feature proved to be so easily obtained and of such decided advantage that it was incorporated in all the triple valves designed for use in trains of more than two cars.

Referring to figure 4, showing in quick service position the quick-action triple valve already described, it will be observed that the port *q* connects with port *t*, which leads to the top of the emergency piston instead of directly to the brake cylinder, as in the preceding valve. This arrangement was simply a matter of convenience, as the port *t* was already conveniently located for the purpose, and the emergency piston is of sufficiently loose fit to allow the relatively small amount of air thus discharged to pass readily around it and to the brake cylinder, without any danger of causing the quick action parts to move.

Referring to figure 4, it will be noted that when quick-service port *y* registers with port *o* in the slide valve, the service ports *d* and *r* only partially register; the air flowing through these ports from the auxiliary reservoir to the brake cylinder, is thus restricted in amount, which limits the rate at which the auxiliary-reservoir pressure reduces. If the brake-pipe pressure reduces more rapidly than does the auxiliary-reservoir pressure, the predominance of pressure in chamber R will enable the piston to somewhat compress the graduating spring and move the slide valve to the " full service " position. In this position, port *y* is closed, preventing a flow of air from the brake pipe to the cylinder, while port *r* is fully open, allowing a more rapid flow from the auxiliary reservoir to the brake cylinder, so that the reduction in auxiliary-reservoir pressure may keep pace with that in the brake pipe. In this way, the triple valve automatically cuts out the quick-service feature when it is not needed.

The features considered above, which were so successfully incorporated in valves intended particularly for traction service, afforded, at the same time, a means for securing certain results which had long been desired, but heretofore never obtained in steam road operation. It is evident that the quick action valves which have been referred to can be applied with equal success to steam road equipments. In handling freight trains particularly, the quick service feature is of especial advantage. It enables the brakes to be applied by a service reduction from the head to the rear end of a train of any length at a more rapid rate than the slack could run in, thus preventing the disastrous results often arising from that source.

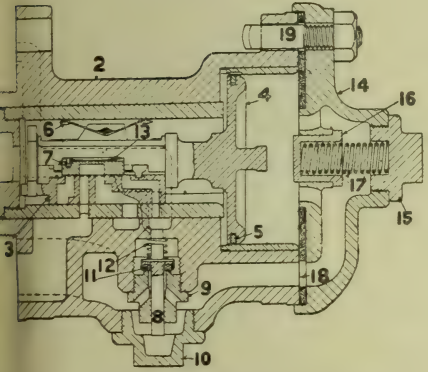

Fig. 11. — Section through type T triple valve.

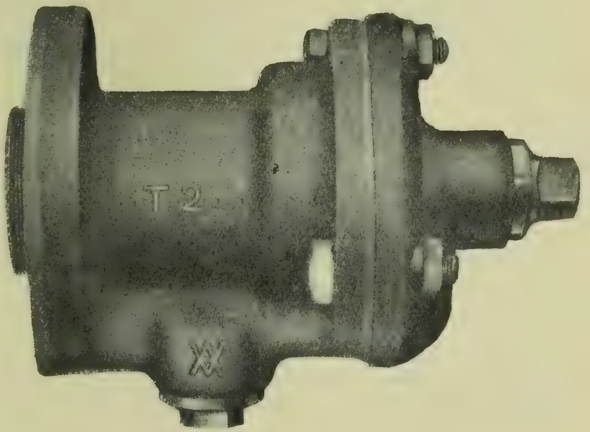

Fig. 12. — Type T triple valve.

For a similar reason, it had long been desired to effect as nearly as possible a simultaneous release of all the brakes in the train, so as to prevent the running out of the slack from the head end which, when releasing the brakes on a train of any considerable length at slow speeds, is often the cause of such severe strains on the draft gear as to part the train. To explain how this may happen, suppose the brakes to have been applied and the speed of the train reduced to 5 miles per hour. If a release is then made, without coming to a full stop, the brakes on the forward cars release first, allowing these to pull away from those farther back, on which the brakes still remain applied.

As is well known, it is impossible to force the air back through the brake pipe, when making a release, either in amount or at a pressure sufficient to effect the release at the rear of a long train, until some time after the brakes at the head end are fully released. This is due not only to the friction in the pipe, but also to the fact that the air necessary to accomplish the desired result is being to some extent absorbed by the recharging of the auxiliary reservoirs all along the line. Consequently, the pressure at the head end of the train which is more than ample to release and fully recharge, falls rapidly as the distance from the front end increases, until, after about the fortieth car, it is almost impossible to raise the brake-pipe pressure fast enough to secure the desired rapidity of release and recharge.

This condition, however, was made use of in an ingenious manner to practically reverse these effects, which before had been unavoidable. Under ordinary conditions of service, an increase of a pound or two pressure on the face of the triple-valve piston is required to move it. A much greater difference than this is obtained at the head end of the train, and this difference rapidly decreases as the distance from the source of supply to the brake pipe is increased. If this greater difference of pressure which is unavoidable at the head end of the train can be utilized to cause the operating parts of the triple valve to move so as to restrict both the release of the brake-cylinder pressure and the recharging of the auxiliary reservoir, evidently the release of the brakes on the forward part of the train will be delayed, and the air forced to flow more promptly and at a higher pressure toward the rear and effect a more uniform release and recharge. In this way, the brakes on the train as a whole can be released almost simultaneously.

Freight triple valves.

Figure 13 shows the new freight triple valve, a simple modification of the standard type, which carries this principle into effect. The modification consists chiefly in the addition of what is called the retarding-device spring and stem, shown under the letter R. When the brake-pipe pressure is raised gradually, creating only a slight increase in pressure on the brake-pipe side of the piston, its movement toward release position is arrested by striking the retarding device stem as shown in the cut. In this position, the cylinder port *r* has a full opening through the exhaust cavity *n* in the slide valve to the exhaust port *p*, allowing a free flow of air from the brake cylinder to the atmosphere. At the same time, the quick service port *y* is in full register with port *j* in the slide valve, which together with the feed groove *i*, produces the quick recharging of the auxiliary reservoir.

On the other hand, when the rise in brake-pipe pressure is sufficiently rapid to cause enough difference in pressure to compress the retarding device spring, the piston and slide valves are moved beyond the full release position to that shown in figure 14, known as the retarded-release position. In this position, a small narrow extension of the exhaust cavity *n* connects the cylinder port *r* to the exhaust port *p*, which restricts the flow of air from the brake cylinder to the atmosphere; at the same time, the flow or air to the auxiliary reservoir is entirely stopped, so far as the feed groove *i* is concerned, by the piston sealing against the end of the bush, while the feed up through the quick service port *y* now passes through a much smaller port, *l*, in the slide valve. Thus the rate of recharge is greatly retarded. The piston remains in this position so long as the excess pressure on the brake-pipe side remains sufficient to hold the retarding device spring compressed. As this difference becomes less, the spring forces the piston and slide valve together back to the full release position shown in figure 13.

This triple valve, known as the type K (1), also includes the quick service feature previously described, as will be seen by reference to figure 15, which shows the valve in quick-service position.

This feature is of special importance in handling long freight trains, because heretofore it has been difficult to cause all the brakes to apply on a train of over 75 cars, even if a full service reduction is made, with the triple valves all in fairly good condition, for the reason that the standard type of triple valve was not designed to operate under such extreme conditions. The new type K triple valve, however, including as it does the

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(1) Vide *Bulletin of the Railway Congress*, No. 12, December, 1906, p. 1874 : " Diagrams of K triples ".

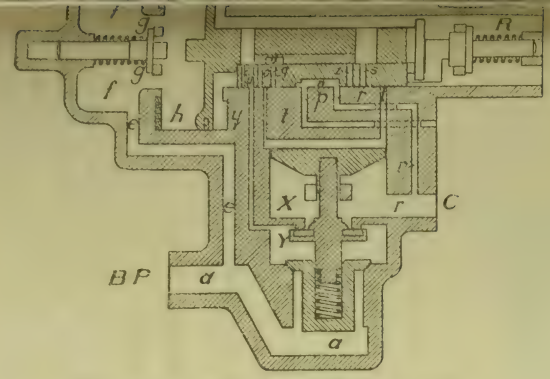


Fig. 13. — Type K freight triple valve; full release position.

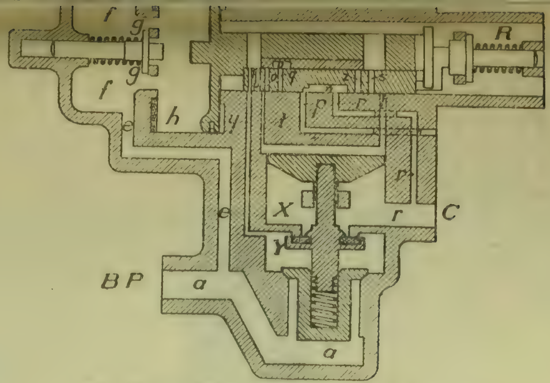


Fig. 14. — Type K freight triple valve; retarded release position.

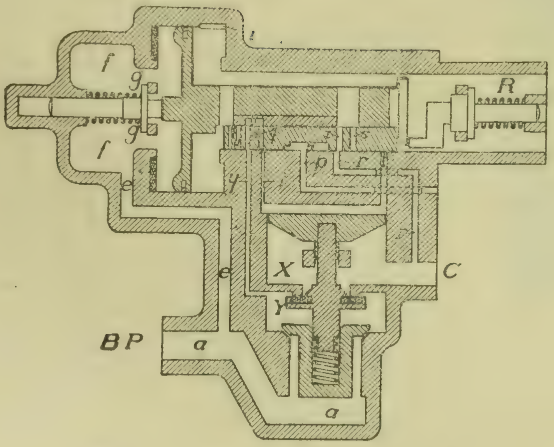


Fig. 15. — Type K freight triple valve; quick-service position.

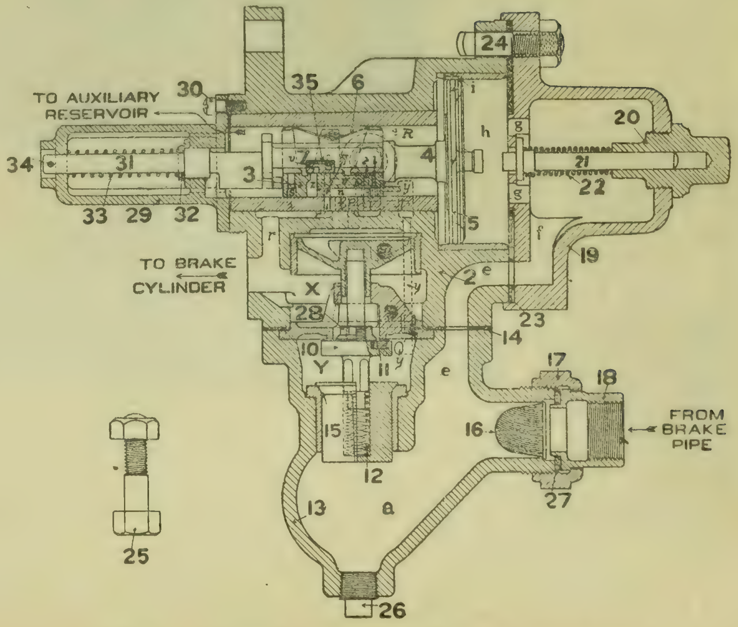


Fig. 16. — Section through type K freight triple valve.

features of quick service, retarded release, restricted recharge of the reservoirs on the head end and quick recharge of those on the rear end, affords complete control of a train of any length. The cuts of this valve, figures 13, 14 and 15, previously referred to, are diagrammatic. Figure 16 shows the valve in true section, while figure 17 is a photograph of the device. Although this valve has a new designation, and includes all the new operative features just mentioned, it is not greatly different from the old standard freight triple valve in construction or appearance. In fact, the standard F36 or H49 (now the H-1 and H-2) triple valves now generally in use in freight service, may be changed into the type K triple by simply adding the retarded release device, substituting a new bushing, slide valve and graduating valve for the old, and drilling the quick service port in the body and check valve case. It will be noticed from the photograph that the retarded release device projects into the auxiliary reservoir when the valve is in position. For the purpose of distinguishing this type of valve readily from the standard types, a rib is cast on the top of the body, extending about half way from flange to flange, which can be easily seen from the side of the car.

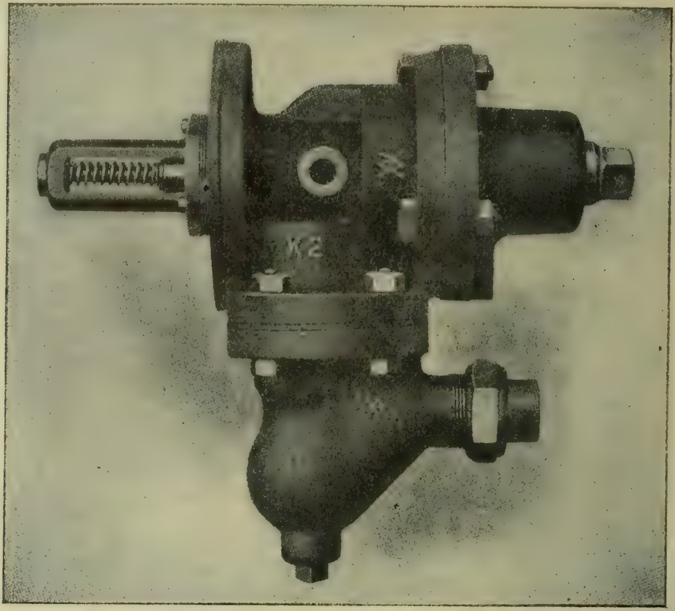


Fig. 17. — Type K freight triple valve.

Graduated release on electric carriages.

In the application of the graduated release triple valves, to electric traction service, the reserve supply of air used to obtain the graduated release feature, was obtained in the following manner : It was necessary for the main reservoirs of all motor cars to be connected through the train in order to equalize the amount of work required from each compressor. This was effected by adding a second pipe line, the pressure in which is always maintained at that for which the feed valve supplying the system is set. This pipe, called the "control pipe," furnished a convenient source for the "reserve supply" needed, as it was then necessary only to make suitable connection between it and the triple valve. In the case of steam road practice, however, this second pipe line did not exist, and it was impracticable to add it solely for this purpose. For this service, therefore, an additional or "supplementary" reservoir was located on each car and connected to the triple valve in place of the control pipe. When the triple valve is in release position, this reservoir is being charged from the brake pipe along with the auxiliary reservoir, and to the same pressure. When this reservoir is charged and an application of the brakes made, the action is precisely the same as when a "control" pipe is used, with this exception : With the control line, the volume of air available at feed-valve pressure is practically unlimited, while with supplementary reservoirs, the reserve supply pressure is limited by the supplementary reservoir capacity. The operation of the two systems is, however, substantially the same, since the supplementary reservoir volume is ample to permit of as many graduations in the release as it is feasible to employ during the stop.

The high speed valve.

Along with the development of the systems which have been described, the conviction had been steadily gaining ground that when a quick stop is made from high speeds, a much greater braking power, and therefore higher brake cylinder pressure, can be advantageously used than has previously been employed. Obviously with a system using a reserved supply, this could be attained by locating a valve, so that when an emergency application of the brakes was made, the supplementary and auxiliary reservoir volumes would unite and flow to the brake cylinder. The brake cylinder pressure thus obtained, would be that at which the brake cylinder, supplementary, and auxiliary reservoir volumes equalized, the increase in pressure thereby secured being obviously considerable. This idea was first applied in practice in exactly the manner above mentioned, by means of a so-called "by-pass valve" located in the piping system. The results secured were so satisfactory that steps were immediately taken to develop this device as a permanent part of the graduated release equipments. In order to simplify the apparatus, the by-pass valve was incorporated into the triple valve itself, thus leading to the development of what is now known as the type L triple valve.

The diagrammatic view of this valve is shown in figure 18. The triple valve includes all of the features of the graduated release triple valves, with the addition of the by-pass valve as shown. Auxiliary reservoir pressure is always on one side of the by-pass piston, and in all positions of the triple-valve slide valve, except emergency position, it also acts on the other side through port *c*. The device is therefore entirely inoperative under these conditions. But when the triple-valve slide valve goes to the emergency position, as shown in figure 19, the air on the left of the by-pass piston is allowed to flow to the brake cylinder through ports *c*, *d*, *q* and *r*, thus creating an excess pressure on the right side of the by-pass piston, forcing it to the left, and allowing the supplementary reservoir pressure to flow from port *x* past the by-pass valve to the auxiliary reservoir. Thus in emergency applications, a volume of compressed air much larger than that contained in

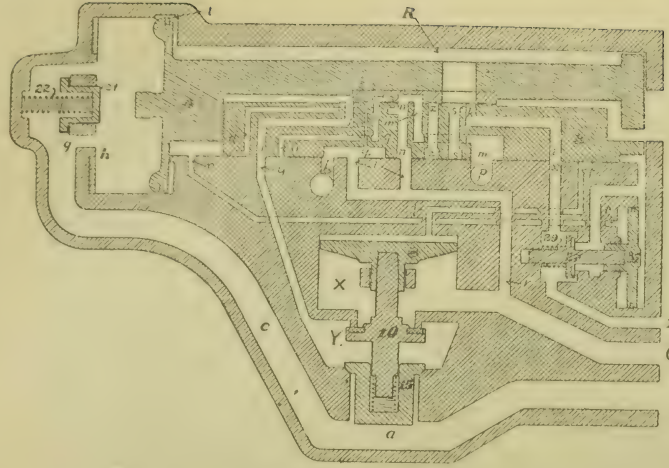


Fig. 18. — Type L triple valve; release position.

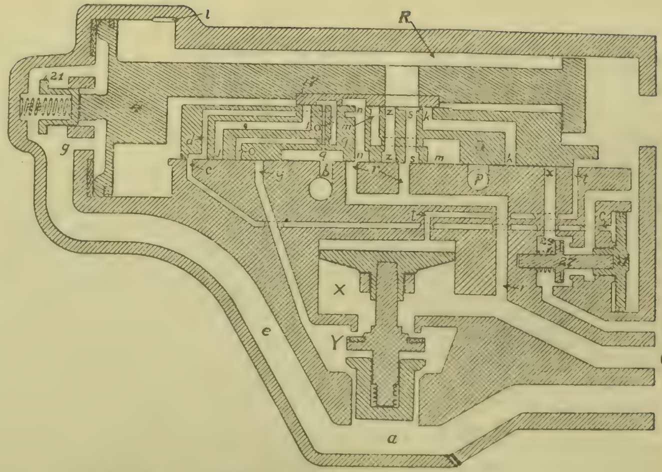


Fig. 19. — Triple L triple valve; emergency position.

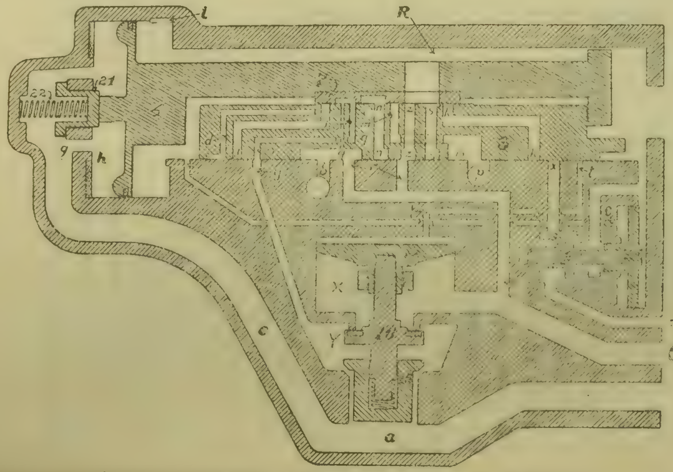


Fig. 20. — Type L triple valve; quick service position.

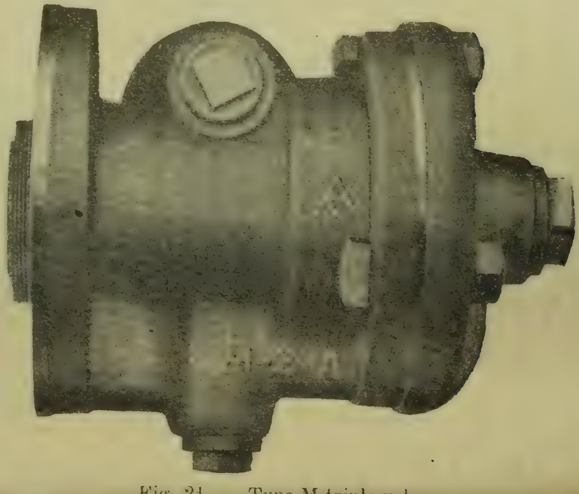


Fig. 21. — Type M triple valve.

the auxiliary reservoir is allowed to flow to the brake cylinder, which increases the pressure of equalization to a very considerable degree. The reasons for adopting the methods described above, whereby a considerably increased brake cylinder pressure is available in case of emergency above that which can be obtained in ordinary service reduction, are as follows :

As already pointed out, it is necessary that not too high brake-cylinder pressures be obtained, when moderate brake pipe reductions are made, in order that ordinary service stops, from moderate or low speeds, may be made with smoothness, accuracy and in such a manner that the engineer can judge accurately his control over the train. On the other hand, when an emergency arises the consideration of safety is paramount. It then becomes necessary to stop in the shortest possible time, regardless of anything else. To do this requires the highest possible brake-cylinder pressure which can be used without actually sliding the wheels.

The high speed safety valve.

In the high-speed brake, the high-speed-brake reducing valve serves to prevent the accumulation of excessive brake-cylinder pressures in service operation. In emergency applications, not only is a higher pressure obtained, but the time during which this pressure is held is considerably lengthened.

The development of this idea is carried one step further in the type L triple valves. The service operation, so far as the amount of brake-cylinder pressure obtained is concerned, is no different than before. The high-speed reducing valve is replaced by a safety valve which forms a part of the triple valve and is connected directly to the brake cylinder pressure when the piston is in service position, as shown in figure 20. Port *b* leads directly to the safety valve, and in the position shown is connected through cavity *q* to the brake cylinder port *r*. This serves the necessary purpose of limiting the brake cylinder pressure obtainable in service reductions to the adjustment of the safety valve.

But in emergency applications, it has been demonstrated by tests and actual service on the road that, when running at high speeds, the high cylinder pressure obtained with the L triple valve in an emergency application can safely be held without any reduction, to the end of the stop, and this without increasing the danger of objectionable wheel sliding. The L triple valve was accordingly designed so that when the piston moves to emergency position, the connection between the brake cylinder and safety valve, as described above, is cut off, this position of the ports being shown in figure 19. In this manner the equipment comprehends, within the triple valve itself, the functions of the present high-speed brake, with the addition of the quick service, graduated release, quick recharge and augmented emergency brake cylinder pressure features.

High speed traction service valve.

This latter feature of augmented emergency brake-cylinder pressure is equally valuable in connection with high speed traction service, where it may not be advisable to use a triple valve with quick action features, as in case of the cars operating singly, as well as in trains. The next step taken was therefore to incorporate this feature in the type T triple valve already described, the new valve being called the type M triple valve. A photograph of this valve is shown in figure 21. A detailed description of it is unnecessary inasmuch as it corresponds throughout with the tye T triple valve, except for the addition of the by-pass valve just explained in connection with the type L triple valve. In the type T triple valve, no higher brake-cylinder pressure could be obtained in emergency than in service operation; whereas with the type M triple valve, while the cylinder pressures obtained in service reductions are kept down to the required limits for flexibility at moderate speeds, a considerable increase in brake-cylinder pressure can be obtained when any occasion arises for making a quick stop from high speeds.

Straight-air, with automatic emergency feature,

One of the novel and ingenious developments in connection with the application of air brakes to traction service is what is known as the straight-air brake equipment with automatic emergency feature. During the time that electric traction service was confined entirely to single car operation, the straight air brake equipment met all reasonable demands and was largely adopted. But it soon became desirable to operate two cars together for either a portion of the time or continually. As has been already pointed out, good practice demands that in such cases, some safety feature be incorporated in the

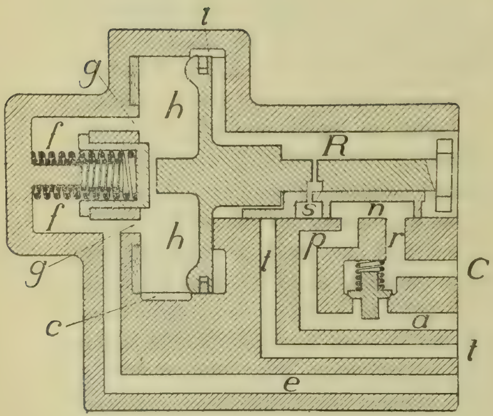


Fig. 22. — Emergency valve.

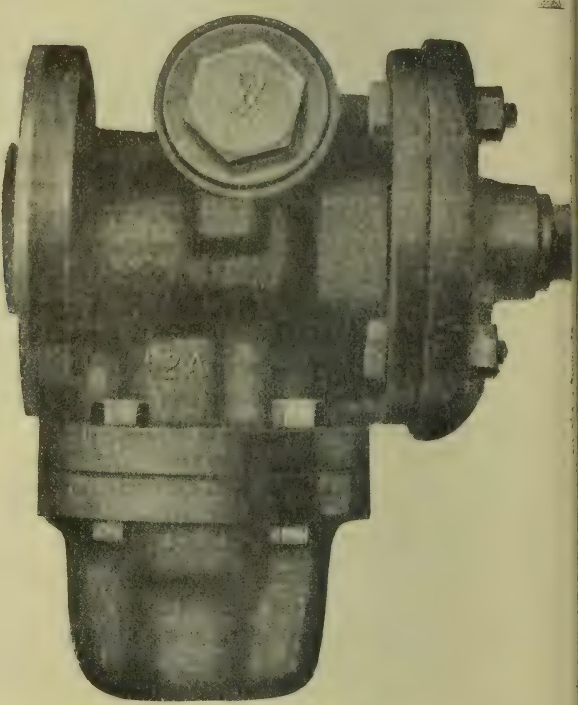


Fig. 23. — Type L triple valve.

brake system, whereby, in case of a break-in-two or rupture in the piping, the brakes on both vehicles will be automatically applied. As the straight air system had already been made standard for such service, and it was often not desirable to change over to a new system of operation, *viz.*, the automatic, in order to secure the necessary safety feature, some method was required whereby the straight air system could be made to operate automatically in case of emergency. This was accomplished by the addition of a device called the emergency valve, shown in figure 22, and an additional pipe line. This latter is normally under pressure and connected to the emergency valve at *e*. Chamber R is connected to the main reservoir which is supplied with air by the compressor. In ordinary service operation, the air brake operates as a straight-air system, the air flowing directly to and from the brake cylinder from the brake valve through the usual straight-air pipe. But when an emergency application of the brakes is made by the motorman, or where a break in two or other accident causes any rupture of the piping system, a sudden reduction of pressure results in the pressure pipe, causing a reduction in port *e*, which communicates to the chamber *h*, behind the valve piston. The air being unable to flow fast enough from the reservoir side R of the piston through the feed grooves *i* and *c* to keep up the pressure, a differential pressure sufficient to move the piston and its attached slide valve is caused. This opens the port *r* leading from the main reservoir to the brake cylinder, and applies the brake automatically. The brakes would then be released through the brake valve in the ordinary manner.

This equipment, therefore, furnishes a system of straight-air control which gives perfect satisfaction in single or two car operation, for the particular kind of service outlined above, with the automatic application of the brakes always in reserve as a safety feature in case of necessity.

Locomotive brake equipment.

The treatment of this subject of developments in air brake control apparatus would hardly be complete without mentioning the so-called " ET " locomotive brake equipment. This equipment has been so thoroughly described in the technical press and before various societies, that a detailed description of it here does not seem necessary. It need only be said that by it the installing and handling of locomotive brakes has been so simplified and improved that it is being quite generally adopted as standard equipment. Before its introduction, the value of the locomotive brake in developing a retarding effect on the train, as a whole, was very uncertain. The almost constant use of the locomotive, as well as the difficulty of getting at the apparatus, made its proper maintenance very difficult. As a result, excessive leakage and uneven adjustment often led to such losses in braking power as to render the stopping power of this most important unit in the train, of little value. With the ET equipment, however, not only is the engineer provided with a means of operating the locomotive brakes either in conjunction with or independently of the train brakes, as occasion arises, but the application resulting is always the same for any certain manipulation by the operator, and the cylinder pressure obtained is uniform in all cylinders on the locomotive and maintained during the application to the pressure first obtained, against such leakage as may exist. Many other features both of safety and convenience are incorporated in the details of this equipment in such a way that it has the good points of all previous equipments and eliminates their objectionable features.

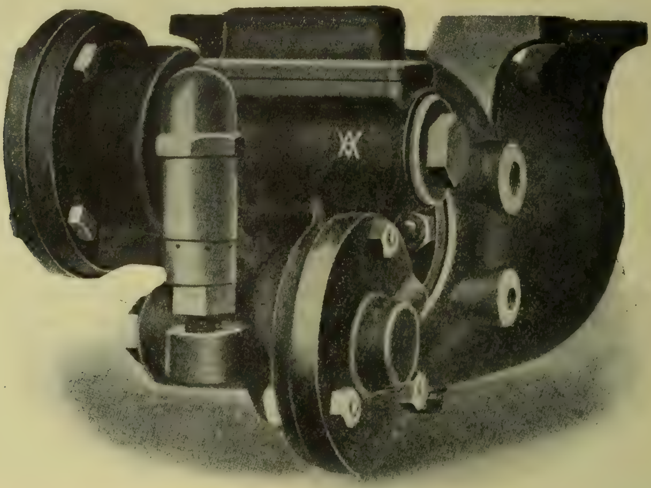


Fig. 24. — Distributing valve; chief controlling mechanism of the " ET " locomotive equipment.

The foregoing gives only the most important changes that have taken place in the art of train braking during the past two or three years. It cannot by any means be said to cover the whole field of progress in this line, but will perhaps serve as an indication of its growth and development. It will, to some, bring home the fact that progress in one line of the mechanic arts compels a like growth in all other lines. The vast development of the resources and industrial establishments of this country have made a similar development of railroad rolling stock indispensable, which in turn has compelled such changes in all rolling stock auxiliaries as will enable them to keep pace with the requirements of the day. These changes are still going on as new conditions arise, so that this article is only a chapter of their history.

[625 .245]

A NEW RAILWAY CAR DYNAMOMETER,

By A. H. EMERY, Jr.

Figs. 1 to 19, pp. 1028 to 1040.

(*American Machinist.*)

The 100,000-pound dynamometer car of the Pennsylvania Railroad, its recording mechanism and the record it produces.

The problem of determining and making a record of what the reciprocating engine, either stationary or locomotive, is capable of doing, has interested engineers for many years.

On the steam- or gas-engine indicator, a record can easily and accurately be made of the changes taking place in the cylinder; and the measuring of the output of a stationary engine is not difficult and can be accomplished by the use of brakes or of a transmission dynamometer; but in the case of a locomotive, the situation become more complicated.

The most natural way to start is to make the locomotive into a stationary engine for the time being, by supporting its drivers on wheels with supported axles, and applying the brakes to these axles in such a manner that they absorb and at the same time measure the output of the locomotive. It is, of course, necessary to fasten the drawbar to some stationary support to take the pull and keep the axles of the drivers exactly, or very nearly, over the supporting wheels. Then, by measuring the indicator horse-power and the brake horse-power, and making the necessary corrections for friction of the bearings of the supporting axles, the efficiency of the locomotive can be obtained under any desired set of conditions.

The next step is obvious and is to measure the pull or push on the drawbar, thus measuring the amount of force which the locomotive can exert on the train.

Various testing plants have been built on this principle, either with or without the dynamometer for weighing the drawbar pull. A description of several of these, by professor W. F. M. Goss, will be found in the reports of the Chicago meeting of the American Society of Mechanical Engineers, in May and June, 1904.

The latest plant of the kind mentionned, is the one built by the Pennsylvania Railroad Company, exhibited at the St. Louis Exposition, and now permanently installed at

Altoona, Penn. The dynamometer, or apparatus for weighing the drawbar load, was built by William Sellers & Co., Inc., Philadelphia, Penn. This plant has already been described in the December 15, 1904, issue of the *American Machinist*.

With a plant of this kind, interesting, valuable and exhaustive tests can be made on the locomotive, but nothing can be determined in regard to the load necessary to haul trains of various lengths and weights over various grades or curves, of the difference in efficiency of a locomotive used alone or in tandem, or used as a " pusher." For this class of tests, it is neccessary to have an instrument which can weigh and make a record of the pull or push between the locomotive and train, and it is such an instrument that the writer wishes to describe.

In 1886, or thereabouts, the Pennsylvania Railroad ordered such a dynamometer of the Yale & Towne Manufacturing Company, of Stamford, Conn. It was designed by Albert H. Emery and calibrated by him and A. S. Vogt, mechanical engineer of the Pennsylvania Railroad. The instrument was placed in a suitable car by the Pennsylvania Railroad engineers, who also designed and built the mechanism for driving the paper on which the record was made and the instruments for recording the speeds of the train, etc. This dynamometer had a maximum capacity of 28,000 pounds, and the recording pen had a maximum movement of 7 inches above the base line. The value of 1 inch of movement was therefore 4,000 pounds, and was constant under all conditions. Many tests were made with this car, and a great deal of valuable information obtained, but it gradually became inadequate to the demands upon it, as can readily be seen from one fact alone, that a modern, heavy freight locomotive can pull over 40,000 pounds, or 50 per cent more than the maximum capacity of the dynamometer. The need for a machine of larger capacity increased as the number of large locomotives and heavy trains increased, and finally a contract was made by the Pennsylvania Railroad Company with Mr. Emery to design and build another dynamometer, to have a maximum capacity of 100,000 pounds and a maximum movement of the recording pen of 10 inches; the motion to bé in the same direction from the base line for either push or pull, and the apparatus to be adjustable so that the value of 1 inch of motion of the pen could be made to be either 1,000, 2,000, 3,000, 4,000, 5,000, 6,000, 7,000, 8,000 or 10,000 pounds. The railroad engineers were to design and build the car, the paper-drive mechanism, and such other apparatus as they desired for additional records. This dynamometer was built and calibrated by Mr. Emery, most of the work being done at the Bridgeport works of the American & British Manufacturing Company, while the car, instruments, etc., were designed in the office of the mechanical engineer of the Pennsylvania Railroad, A. S. Vogt, at Altoona, Penn., and built in the Juniata shops.

In order to interpret correctly and easily the meaning of the record made by the dynamometer, several other records are necessary or desirable.

The paper on which all of these records are made is 18 inches wide, is driven by gearing from one of the axles, and moves under the pens at a rate of 52·8 inches per mile travel of car. Near one edge of the paper, there is a pen to rule a zero or a base line, above which the pen of the dynamometer makes its record. Besides these two, there are eight electrically operated pens, making the following records :

1° Which shows whether the load is push or pull;

2° Which records the integration of the area between the dynamometer record and the base line, or a line parallel thereto;

3° Which makes a time record every one, two, or more seconds,, as may be desired;

4° Which records the distance traveled by the car;

5° and 6° Which are operated from the engine, and are used to show when indicator cards are taken, and to note the boiler pressure and the position of the throttle and reverse lever, by a suitable code;

7° Which is operated by an observer at one of the windows and used for locating mile posts, etc.;

8° An "extra" to be used in any way desired.

All the recording pens are in a straight line across the paper.

The record.

In figure 1 are shown portions of a record taken on one of the test runs. This record was made with a very heavy feight engine in first-class condition, pulling a train of 52 loaded cars, each of 100,000 pounds' capacity, but carrying about 20 per cent overload, so that the total weight of the train, including the dynamometer car, was 7,600,000 pounds. At the point where this record was taken, the engine was on an up grade and had been obliged to slow down for a block signal, and was thus taxed to its utmost to get the train over the crest of the grade. At the left of the record, the average pull is increasing and the speed diminishing, while at two places, the sand stopped running and the drivers slipped, causing the pull to drop down very decidedly. At A, the engineer shut off steam and the local changed to push momentarily, as is shown by the jog in the first line above the dynamometer record; but, as there is a throttling valve in the system, which is equivalent to a dash-pot, the pen did not have time to get to zero before the action of the brakes caused the load to become pull again. An attempt was then made to start the train with the reverse lever down in the corner, but again the wheels slipped and the train stalled. A second attempt, however, was successful, and the train pulled over the crest of the grade, the speed increasing but the average pull keeping about uniform, until at B the reverse lever was hooked up to the tenth notch, and the pull at once decreased. The value of an inch of ordinate on this run was 5,000 pounds, and as the maximum ordinate just before the train stalled at A is 9·375 inches, the pull was 46,875 pounds, and the average pull for the next 550 feet of travel of the train was 43,000 pounds.

The second record above the dynamometer curve is made by a pen operated from a mechanical integrator, and every notch has a value of 1 square inch of area between the dynamometer record and a base line. As the value of an inch of ordinate in this case is 5,000 pounds, and as 1 inch movement of the paper equals 100 feet travel of the train, each notch has a value of 500,000 foot pounds of work. Every fiftieth notch is skipped, as at D, so that they can be rapidly added up to get the total work recorded between any two points on the record. If the base line for the integrator and for the dynamometer record coincide, then the integrator record gives the amount of work done by the engine; but as the integrator works more accurately if its base line is below that

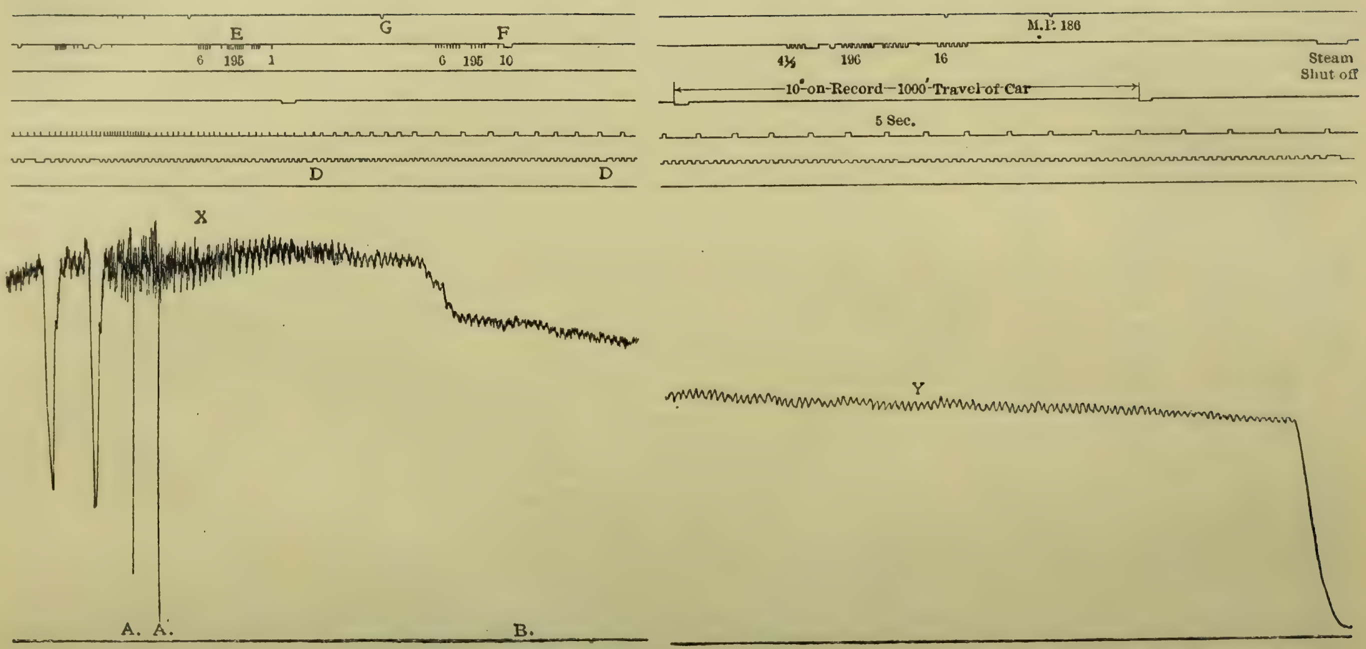


Fig. 1. — Record made by heavy freight locomotive 1 inch in height of curve –5,000 pounds drawbar pull.

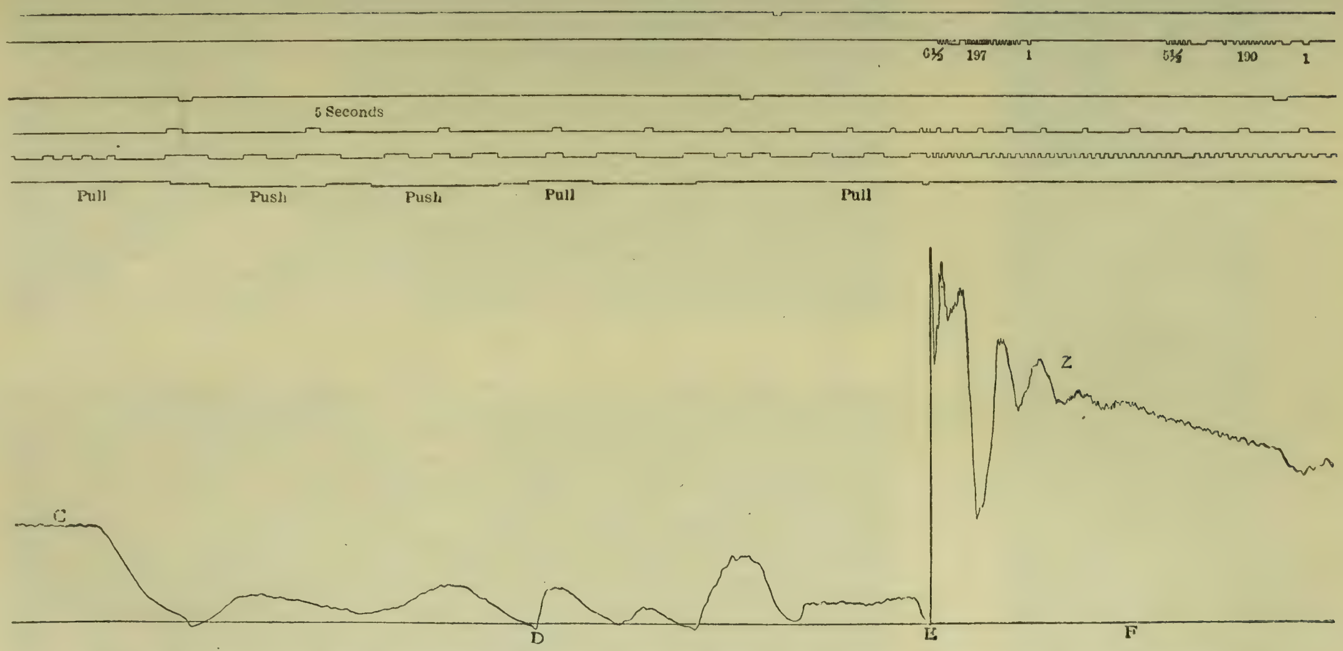


Fig. 2. — Record made in stopping and starting a ten-car passenger train 1 inch in height of curve—5,000 pounds drawbar pull.

of the dynamometer, there will usually have to be a correction made, which depends only upon the original setting of the integrator and the distance travelled by the train, and is independent of the height of the ordinate of the dynamometer record.

The next record is made every five seconds, and it is easily seen that the number of the notches per inch is a measure of the speed of the train. As the motion of the paper under the pen is at all times exactly proportional to the motion of the car, a scale can readily be graduated to read in miles per hour. As one hour equals 3,600 seconds, it contains 720 five-second intervals. As 52·8 inches motion of the paper equals 1 mile travel of the car, of the speed were 1 mile per hour the notches would be 0·0733 inch apart if it equalled 2 miles per hour, they would be 0·1466 inch apart, etc.

The next record line has a notch in it every time the paper travels 10 inches or the car travels 1,000 feet, and this gives a quick method of measuring the distance the car has traveled between any two points on the record.

The next record pen was not used on this run, but is used when indicator cards are being taken on the engine, and it makes a notch in the record line whenever a card is taken.

The sixth record is made by a telegraph key in the engine cab, and shows in this case the number of notches opening of the throttle, the boiler pressure, and the reverse-lever notch; as at E, the throttle lever was in the sixth notch, the boiler pressure 195 pounds, and the reverse lever has been moved to the tenth notch.

The record above this is made by a telegraph key operated by a lookout at the car window. The observer presses the key when passing any point which will aid in locating the record in regard to the track, as a station, mile post, bridge, signal tower, etc., and he calls to the observer at the table, who notes on the record paper what this notch means. A notch is also made every five minutes, exactly on the second, as at G. With these records and the indicator cards, knowing the weight of the train, the grades, etc., many useful results can be worked up.

The part of figure 1 on the right was made when the train was running at a slightly increasing speed of from 11·2 to 13·6 miles per hour, the pull varying from 26,650 to 25,250 pounds.

The record shown in figure 2, was made with a passenger locomotive pulling a 10-car accommodation train. The value of the ordinates is 3,000 pounds per inch, and so, at the right, the record shows the drawbar pull to be 6,450 pounds; and, as the notches in the time record are for five-second intervals, the train was making a speed of 40·9 miles per hour. At C, the throttle was closed and the pull ran down to zero; then application of the engine brakes caused a push between the train and the engine of nearly 2,000 pounds, and later of 2,700 pounds. That the record changed from pull to push is shown by the first record above the dynamometer record, where the pen draws the line above its normal position when the load is pull, and below it when the load is push. At this time, the mechanism had not been quite correctly adjusted, so that, while it recorded correctly the instant the load changed from pull to zero, it did not show the change from zero to push until the push became quite considerable.

At D, the application of the train brakes was sufficient to cause a pull between the locomotive and train, which varied from zero to 4,500 pounds, as the train slowed up, and finally stopped at E. In order to see how much the locomotive could pull in starting

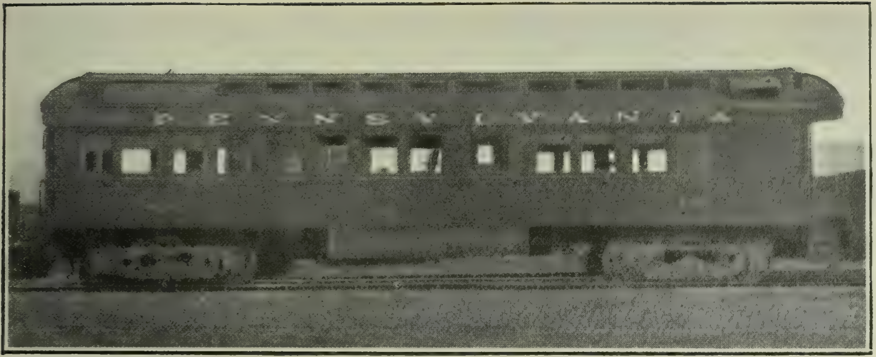


Fig. 3. — The dynamometer car.

Fig. 4. — General view through car.

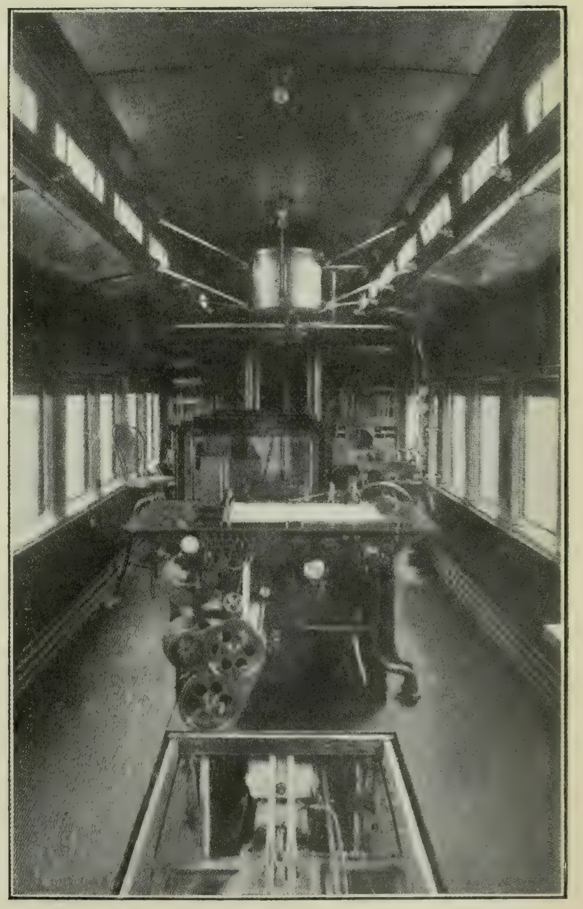


Fig. 5. — Work room from center of car.

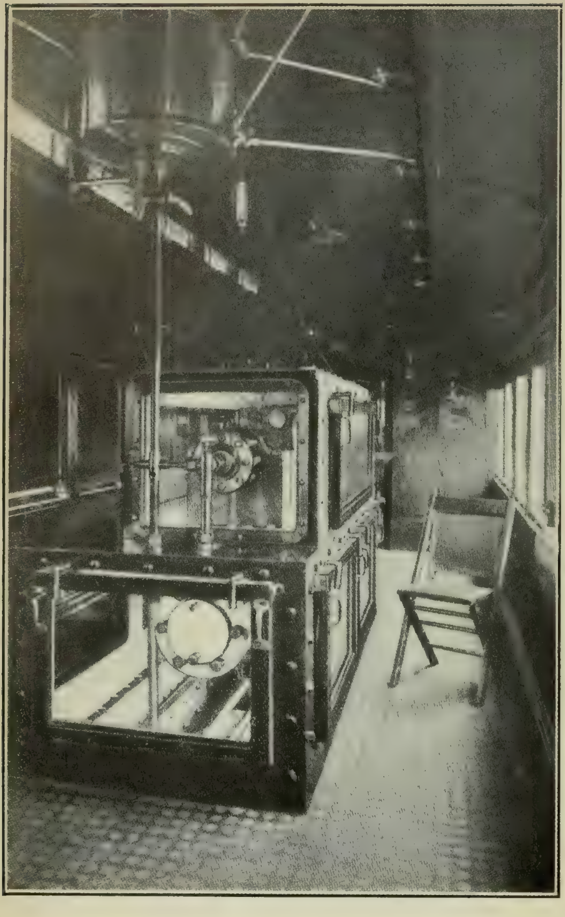


Fig. 6. — The work room.

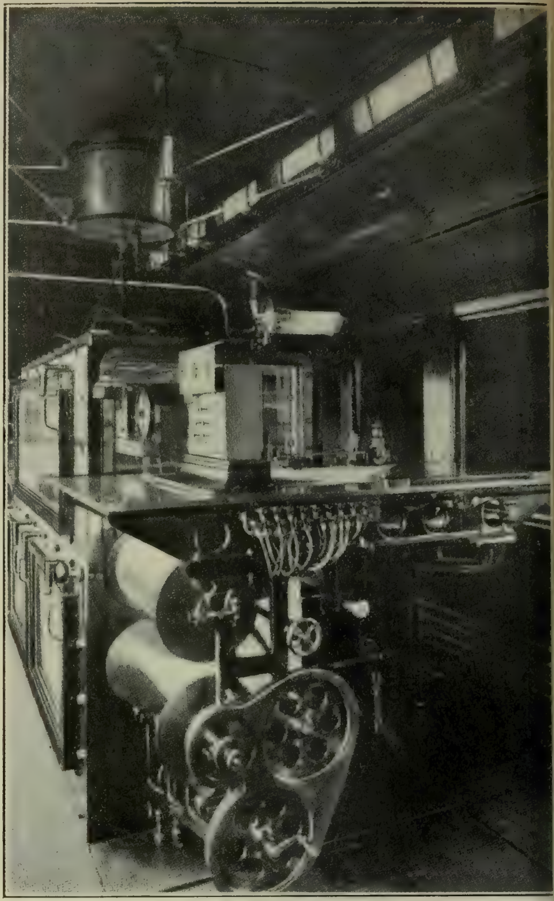


Fig. 7. — The paper drive and table.

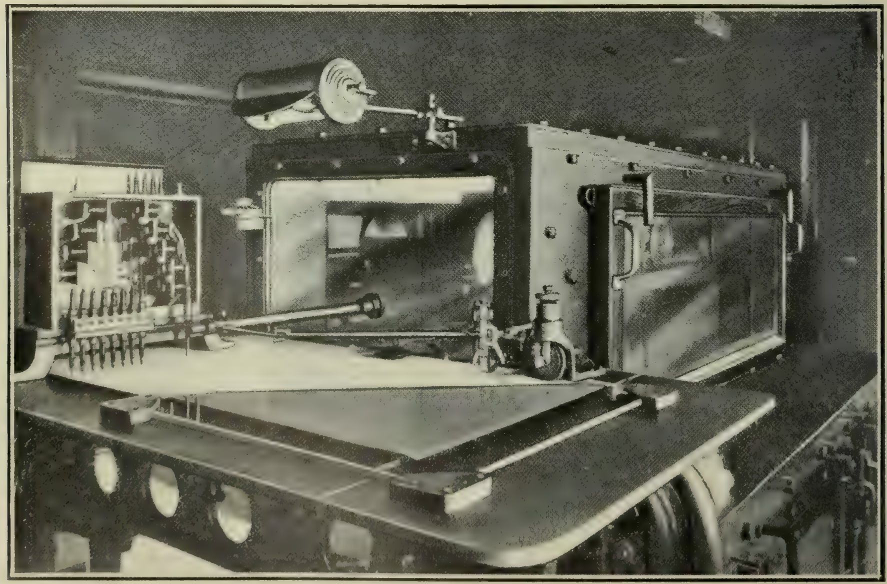


Fig. 8. — The paper table and instruments.

the train, the engineer was ordered to put the reverse lever in the first notch; that is, to give the greatest amount of valve opening possible, and start the train as quickly as he could. The result is readily observed, for, in going the 440 feet from E to F, the speed increased to 15 miles per hour in 40 seconds, and the drivers slipped four times.

In each of these records, each cycle of motion is made during one revolution of the drivers. In the records made by the freight engine at low speed, the beginning of each piston stroke can be easily discerned. On one run where the car was at the rear of the train, and a second pusher behind the car, when both pushers were working with the train on a very heavy grade, all eight impulses on the pistons (as the valves were opened) can readily be seen.

Figures 9, 10 and 11 show full-sized sections of the dynamometer curve, referring to particular points on the curves of figures 1 and 2.

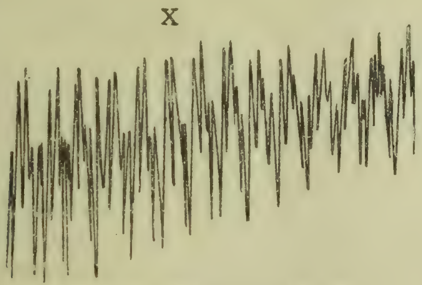


Fig. 9. — Full sized record at X, figure 1.

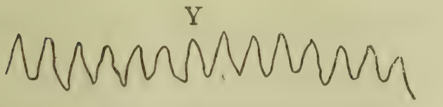


Fig. 10. — Full sized record at Y, figure 1.

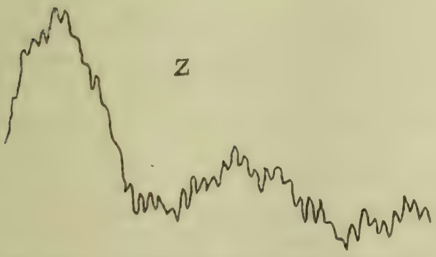


Fig. 11. — Full sized record at Z, figure 2.

General arrangements of the car.

Figure 3 is a photograph of the car complete, its length over end sills being 47 ft. 6 in., and its weight 108,000 pounds. In general, the internal arrangement is as follows :

At the platform end, on one side of the aisle, are a hot-water heater and a large closet for supplies, paper, ink, etc. On the other side of the aisle, is a closet for coal, oil, etc., and a large closet in the lower part of which is a case in which the recording springs of the dynamometer are kept immersed in oil when not in use, the upper part of the closet being used for coats, etc. These closets are lighted with electric lights, which are turned on by the opening of the doors.

The living room comes next, takes a space of four windows on a side and contains four upper berths, two sofa beds and two cabinet beds, also several chairs and a table which can be taken apart and stored under the berths. Here the results of the runs can be worked up, or the room used as a dining room (utilizing electric cooking utensils), or for sleeping quarters.

Next come the lavatories, and then the working room, which has eight windows on either side.

The provision for electric current consists of four sets of storage batteries carried in closets under the car floor, each battery consisting of sixteen 2-volt cells. The lamps and small motors are built for 65 volts. These batteries are usually charged from outside sources, but when off on a long trip this may not be convenient; for this reason, an 85-volt dynamo is installed in the car, direct driven by a kerosene engine.

The trucks are extra heavy, and the second or inner pair of wheels on the truck at the platform end of the car are not provided with brakes, but are accurately turned to such a size that the axle has a certain number of revolutions per mile-travel of the car. This axle carries a spiral gear which drives a shaft running longitudinally of the car, which eventually drives the paper across the table under the recording pens. The drawbar at the bobtailed end of the car is the one which connects with the dynamometer.

General principles of the dynamometer.

Before designing the dynamometer several different systems were considered. Finally it was decided to use an hydraulic apparatus in which all the load on the drawbar is transmitted directly to the piston of a large, double-acting hydraulic cylinder, the cylinder being fastened to the frame of the car and having valves so arranged that, no matter whether the load is push or pull, the end of the cylinder carring the load is in communication with a smaller cylinder, and the other end of the large cylinder is in communication with a supply tank. The small cylinder contains a piston which the liquid endeavours to force out, but the motion of which is resisted by compression springs, which compress until their resistance exactly balances the hydraulic load on the piston. Knowing the relative areas of the two pistons, and the rate of the springs (that is, the amount they will compress for a certain change of load), the load on the drawbar, corrresponding to any compression of the recording springs, can readily be determined. Also, by putting in various sets of springs, the value of an inch of compression can be varied.

An extension of the piston rod which carries the pistons of the recording cylinder carries a pen, which moves over the paper on which the record is made, and the distance of this pen above the base line measures the amount of load on the drawbar.

After the design was completed and the work started, it was learned that the Chicago, Burlington & Quincy Railroad had also designed a car on the same principle, but neither designer knew of the other's work.

Figure 4 is an interior view of the car, looking from the door at the platform end, and it gives a very good idea of the sleeping apartment, and shows the doorway leading into the workroom. Figure 5 is taken from this doorway and shows the workroom, the trap door over the main press being removed; the two pipes leading from the main press to the recording cylinder and to the supply tank, and a portion of the main press itself can be seen, while at the right appear the engine and dynamo already mentioned.

Figure 6 gives a very good idea of the workroom, looking from the other doorway.

All the parts of the main press, drawbar, safety springs, etc., are carefully protected from dirt by being in a closed chamber, but the action of the parts (except the main press) can be watched through the windows in the lower case, which, if necessary, can be very quickly removed. The recording springs, cylinder, etc., are in an entirely separate case over the other.

The paper-driving mechanism.

Figure 7 gives a very good idea of the paper-driving mechanism. In the forward end of the lower case is a vertical shaft which is connected by gearing to one of the car axles, as already mentionned. On the upper end of this vertical shaft, is a bevel gear which meshes with two gears running on a horizontal shaft. This horizontal shaft projects out through the case and is the lower shaft in figure 7, or the one with the crank handle. On this shaft, splined to it between the two bevel gears, is a collar provided with teeth, which can mesh with corresponding teeth in the hub of either gear, and this collar is controlled by a handle seen under the recording table. When this handle is in a central position, both gears run free on the shaft, but if it is pulled out, the splined sleeve moves and meshes with one of the gears driving the horizontal shaft; or, if it is pushed in, it meshes with the other gear and drives the horizontal shaft in the opposite direction. In this manner the operator can stop or start the paper in either direction at will. The small hand wheel beside this handle controls the throttle valve which throttles the motion of the liquid between the main press and the recording cylinder.

The paper is carried in rolls. The supply roll is the upper one shown, and the paper goes from there up through a slit in the table, over the top of the table under the pens, down through a second slit in the table, under a guide roll, back underneath the table, then down vertically to the driving roll and over on to the receiving roll, which is friction driven and which always moves fast enough to keep the paper taut. The drive roll is of bronze, with its surface slightly roughened, and its diameter is so proportioned to the diameter of the car wheels that the paper has exactly the desired motion per mile travel of car. A rubber-covered roll presses the paper firmly against the drive roll, so that no slip shall occur.

Figure 8 shows the paper table, with the rod from the dynamometer recording cylinder projecting through the glass front of the case and carrying the pen which is making the record. Resting on the paper, almost below where the rod comes through the glass, is the instrument for ruling the datum or zero line, while next to it is the mechanical integrator.

The integrator wheel, usually standing at an angle to the motion of the paper, has a tendency to cause the paper to slip sideways; to correct this, the instrument at the right is provided, which consists of a rubber wheel, rolling on the paper, which wheel can be set to roll at an angle with the paper. Beneath this rubber wheel, set in the face of the table, is another wheel the diameter of which is very carrefully made, so that this wheel will have one revolution for every 10-inch motion of the paper; an electric contact carried by this weel makes the 1,000-foot record already referred to. At the left, is seen the bank of eight pens the action of which has already been described. These are moved by magnets controlled by make and break contacts, or telegraph keys. One corner of the paper is covered by a sheet of glass on which the operator can rest his arm when making notes, without any danger of impeding the motion of the paper.

There are many other minor points of interest about the car, such as the switchboard by which any one of the pens can have the voltage on its magnet fixed at either 2, 4, 6, 8 or 10 volts, without changing the voltage on any other magnet. The details of the method of transmitting motion from the car wheels to the paper are novel, but cannot be here discussed; also, the various provisions made for taking care of the leakage are very interesting. Electrically driven pumps are provided which automatically start when this leakage has reached a certain amount, and stop when the oil which has leaked away has been replaced. There are also indicators, and alarm apparatus to call the attention of the operator if the electric pumps do not work and the hand pumps have to be used.

Details of the design of the dynamometer and some of the difficulties encountered and overcome in the precision work of making it.

It will be remembered that all the load on the drawbar is transmitted directly to the piston of an hydraulic cylinder which is fastened to the framework of the car. A portion of the load on this piston is communicated hydraulically to the piston of a smaller cylinder, and the motion of this smaller piston is resisted by compression springs which measure the load on the drawbar by their compression. In other words, the whole apparatus is comparable with the measuring of the load on the piston rod of a steam engine, by means of an indicator.

Figure 12 shows the general design of the dynamometer and the relative arrangement of the parts, except the supply tank, which is carried above the top of the supper case at its right-hand end.

A hollow box girder is formed of side plates 1 and 2, which run the whole length of the car, and top and bottom plates 3, 4 and 5, which run nearly the whole length of the car; this box girder is stiffened at each end by a heavy casting, and intermediately by several other castings, as at 6, 7 and 8. This girder forms the backbone of the car, is supported by the trucks, and carries the framework of the car and the drawbars. One of the drawbars is fastened in the ordinary manner through a Westinghouse friction draft gear, while the load on the other is transmitted to this backbone through the main press of the dynamometer. The part of this girder between castings 6 and 8 has no top, but is very heavily reinforced on the sides by plates 9 and 10; in the construction, the castings 6, 7 and 8 were very carrefully finished and then riveted up with plates 4, 5, 9 and 10, after which the tops of 9 and the faces of 10, between which the housing 11 fits, were planed to gauges and the ledge on plates 9 planed to an exact distance below the axis of the hole in casting 8. This was a very difficult piece of work to do, as everything had to be exactly right, the faces on 9 all exactly paralled to the center line of the girder and exactly equidistant from the axis of the hole.

The housing 11 fits between and rests upon a ledge on the plates 10, and is held by taper-reamed bolts which transmit all the load on the drawbar to the car frame. This load is transmitted by shaft 13, which extends to the right, nearly to the end of the car, where it is fastened to a large hollow casting which contains a Westinghouse friction draft gear connected to the drawhead. This casting moves in the casting which forms the end of the main girder, and is guided therein by six ball bearings, so that as little loss as possible will occur in friction.

The dynamometer is designed for a maximum load of 100,000 pounds, but in coupling up the train, or in a "run in," a load of 300,000 or even 500,000 pounds might come upon bar 13, and, to protect the mechanism from any undue load, safety springs 15 are put into the system. These springs have to transmit load in either direction, and the safety apparatus consists of three crossheads, the one ot the left fixed to the extension of the piston rod of the main press of the dynamometer. There are four long bolts going through through it and through the other two crossheads, and distance collars around these bolts between the two crossheads at the left. These bolts are fast in the left-hand crosshead, but free to slip in the others.

The rod 13 passes through the right-hand and central crosshead and has round nuts upon it, resting against the crossheads, the crossheads and springs being between the nuts. The springs are given an initial load of 100,000 pounds, which is carried on the nuts on the rod 13, and the nuts on the bolts are all screwed up until they rest against the crossheads; now, for all loads les than 100,000 pounds, in either direction, the apparatus acts a solid bar. On the rod 13 is a shoulder 13A and a collar 14, which are so adjusted that when the piston 17 is in the center of the cylinder, it is exactly 1 $^1/_8$ inches from the ends of the boss on the casting 8 to the shoulder 13A and to the collar 14.

If a pulling load comes on the bar 13, so long as it is less than 100,000 pounds, it is transmitted directly to the piston 17, the spring system acting as if it were rigid; but if it exceeds 100,000 pounds, the springs begin to compress, the central crosshead moving away from the distance collars on the bolts, the right-hand nut on the rod 13 moving away from the right-hand crosshead and the collar 14 moving toward the boss on the casting 8. If the load becomes great enough to compress the springs 1 $^1/_8$ inches, less whatever the piston 17 may have moved, the collar 14 will strike the castings 8, and all the load in excess of that on the springs will be transmitted directly to the backbone of the car.

Should the load be push intsead of pull, the result will be the same, except that the motion of the crossheads will be reversed; that is, the right-hand one will move away from the nut on the four bolts, and the nut on the piston rod at the left of the center crosshead will move away from that crosshead and the shoulder 13A will strike the casting 8.

The main press.

Figure 13 shows the details of construction of the large cylinder or main press, and is a correct drawing to scale in every respect, except that the valves shown in the upper part are actually behind the central vertical plane, while those shown in the lower part are on the same level as the upper ones, but in a plane in front of the section.

The construction of this press, its piston, piston rod, etc., is very easily seen, but there are two points of interest which merit description.

The piston 17 and rod 16 are necessarily heavy, and as only a very small leakage is allowable, they must fit closely, but, as any friction is very undesirable, a close fit is out of the question. Also, any wear due to the constant motion of the piston and rod backwards and forwards as the load changes would increase the leakage, and, what would be worse, might impair the accuracy of the whole instrument. Near either end of the piston rod are parts 31, which contain roller bearings 33, the shaft in the bearing being at right angles to the piston rod and forming the axle of a portion of a wheel 34. These wheels or rockers roll on a track 28, which is carried by compressing springs 30. By carefully adjusting the load on these springs, the weight of the piston and rod can be carried or balanced, so that the friction will be very small and the wear very greatly decreased.

The valves in the main press are so arranged that for either push or pull the side of the piston under load is in communication with the recording cylinder, and the other side is in communication with the supply tank.

Pipe 22, figure 12, leads from the main press to a chamber 46, the liquid entering the chamber through pipe 47 and entering the rear of the recording cylinder. By this throttling valve, a dash-post action is obtained and also the recording cylinder can be stopped off from the main press, allowing the springs to be changed during a run, if desired

In figure 14 details of the valves are shown. In the upper two sections the piston is at the center of its stroke, and the valves are so arranged that both pairs of valves 21 and 40, are open; and the main press is, therefore, open to both the supply tank and the recording cylinder, giving a chance for all the working parts and the liquid to assume a normal position. As soon as the piston 17 moves in either direction, one of the valves 21 closes, the valve 40 on the same side of the piston being pulled farther open, while the valve 21 on the opposite side of the piston is forced farther open and the valve 40 closed. The result is that no matter which way the piston moves from its central position, the liquid on the side which is carrying the load is able to pass through its valve 21 into the pipe 22 and thus to the recording cylinder, while the opposite side of the cylinder is opened through its valve 40, nipple 36, and the pipe connecting therewith to the supply tank, and is kept full of oil.

Figure 15, p. 1040, is a photograph of the main cylinder, piston, piston rod, valves, etc., disassembled.

Figure 16, p. 1040, shows the whole main press complete, ready for assembling in the car.

The recording cylinder.

Figure 17, p. 1039, shows a section of the recording cylinder, with two of the recording springs fastened in place. Figures 18 and 19, p. 1040, are photographs of this part of the

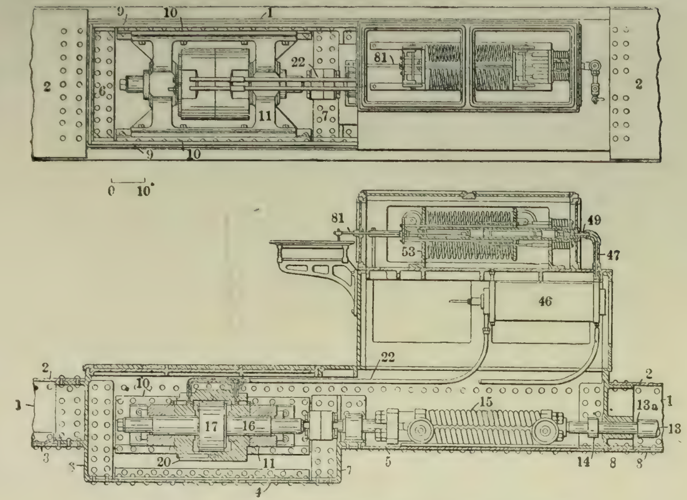


Fig. 12. — General arrangement of dynamometer.

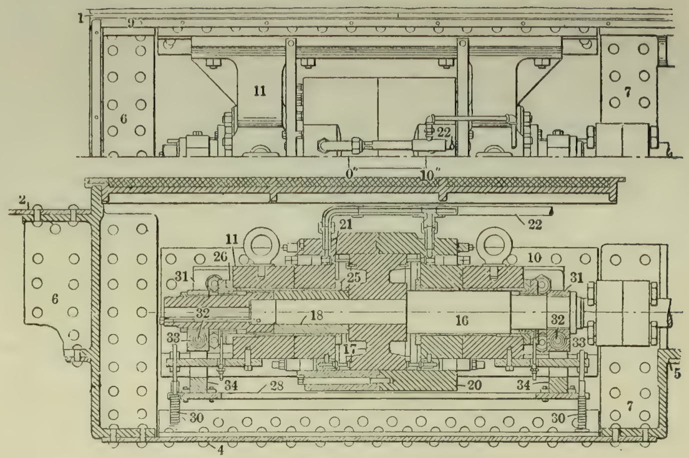


Fig. 13. — Details of main cylinder.

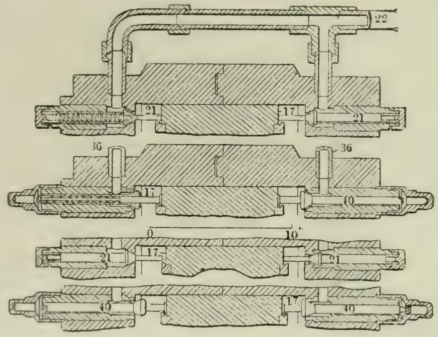


Fig. 14. — Details of the valves.

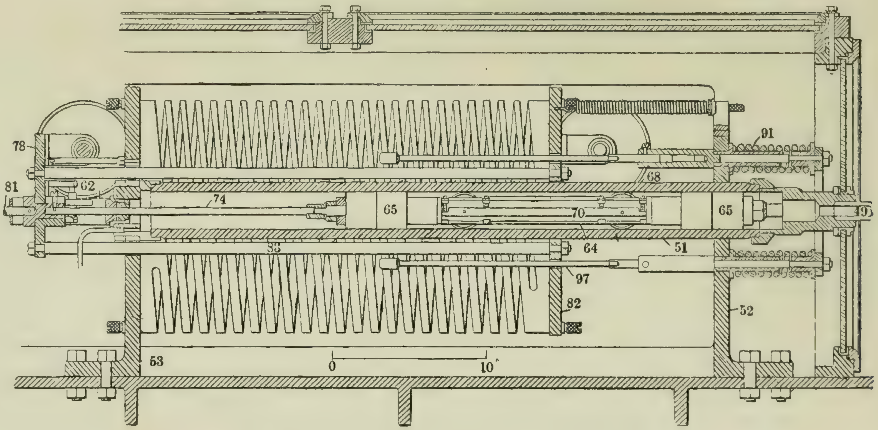


Fig. 17. — Recording cylinder and springs.

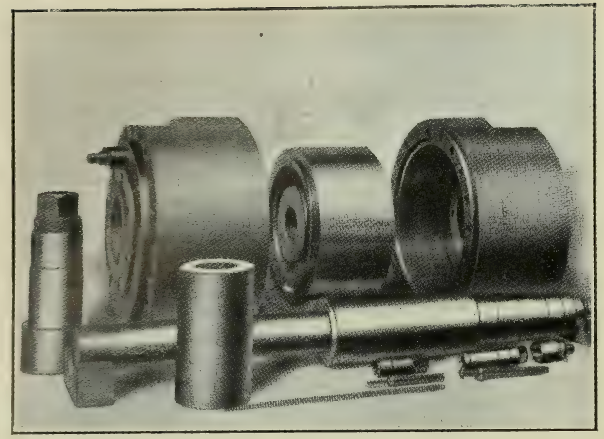


Fig. 15. — Parts of the main press.

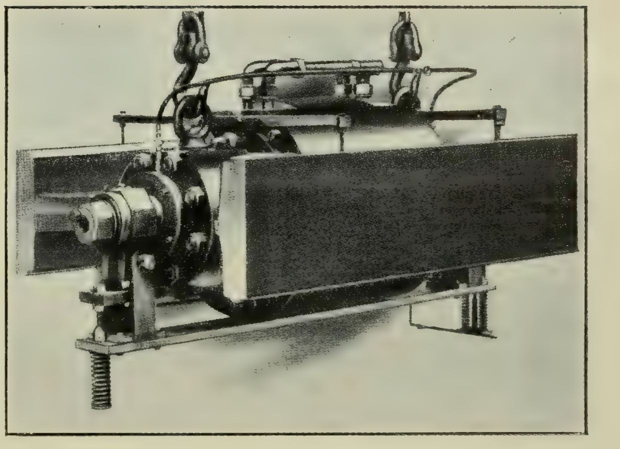


Fig. 16. — The main press complete.

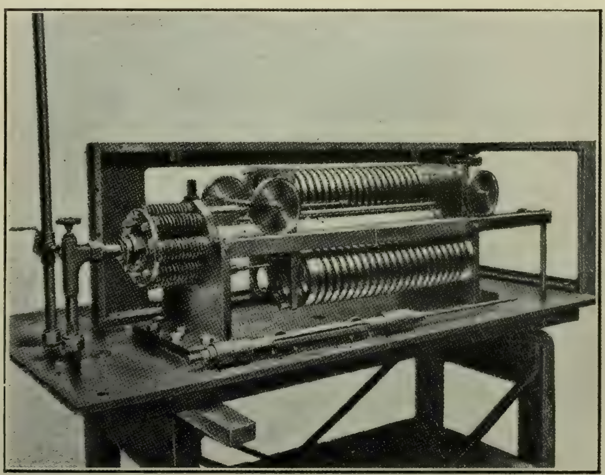


Fig. 18. — The recording cylinder, showing the grooved pistons.

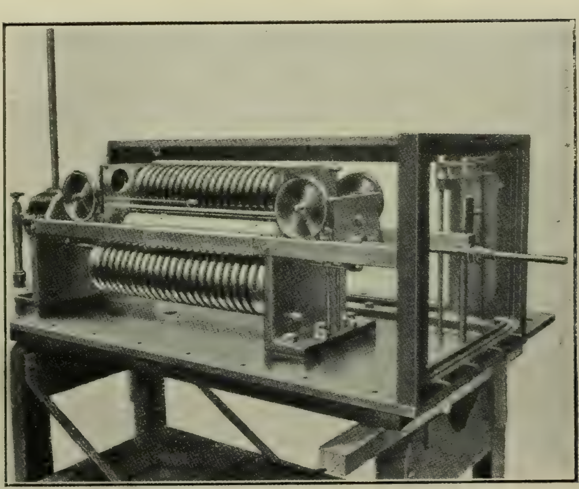


Fig. 19. — The recording cylinder, showing the pen rod.

apparatus. These recording springs and their method of manufacture were described by the writer in the issue of November 29, 1906.

The liquid from the main press enters the recording cylinder through pipe 49, and acts against the pistons 65, of which there are four, to reduce the leakage to a very small amount. In order to reduce the friction and wear, and to get a very long bearing, so that the pistons will have no tendency to cramp in the cylinder, they are placed at the two ends of a long arbor 64; and, to further reduce the friction and wear, this arbor is provided with a pair of rollers 68 whose axles are carried in two side bars 70, the side bars, axles and wheels forming a little truck which carries the arbor and pistons on eight springs which are carefully adjusted so that they just carry the weight of the moving parts. This piston apparatus is clearly shown in the photograph, figure 18, but, unfortunately, is there shown upside down. The two ends of the recording cylinder 51 are supported by angle plates 52 and 53 which carry two rectangular bars 62 which form tracks four a four-wheel truck. Extending from the arbor carrying the pistons is a small rod 74 which connects it to crosshead 78 of this truck. This rod, therefore, transmits all the load on the pistons to the truck.

The recording springs are placed between the other crosshead of the truck and stanchion 53, which supports the cylinder. The outer end of the truck has attached to it a rod 81 which extends out of the case and carries the pen for making the record.

For certain runs, the dynamometer might be used with recording springs which would take their full 10-inch motion with a load on the drawbar of only 10,000 pounds, and, through some unexpected condition, the drawbar might receive a load greatly in excess of the 10,000 pounds, so that some stops should be provided to limit the motion of the springs. Besides, through inadvertence or carelessness, the throttling valve might be left open and the dynamometer receive a sudden load, with no recording springs inserted, and, under these circumstances, the piston, truck, etc., would jump ahead very suddenly, and solid stops are, therefore, inadmissible. The stops provided consist of eight stiff springs 91 arranged around the rear end of the recording cylinder, with stems 97 extending inward through the rear plate of the truck, the stems being provided with heads which receive the load from this plate after it has traversed 10 inches. These springs are assembled with a heavy initial load and are capable of stopping all the moving parts without shock.

Some of the difficulties of the work.

Some of the mechanical difficulties encountered in the construction of this dynamometer, and the expedients resorted to in overcoming them, may be of interest.

At the very outset, the question was raised as to the friction of a close-fitting but unpacked piston, subjected to hydraulic pressure, and some crude experiments were made with a Crosby gage tester, which led to the conclusion that under certain conditions this friction might be greater than would be allowable.

To investigate this question, an apparatus was designed which afterward became the recording cylinder, pistons, etc., of the dynamometer. The cylinder was provided with two holes through its side, midway of its length, so that the space between the pistons could be filled with oil, and the friction of the pistons then measured with various pressures on the oil. As both pistons have the same diameter, the pressure on the oil would not cause any unbalanced thrust, tending to move them in the cylinder.

The cylinder was bored and lapped, and it was so true that careful star gaging from end to end failed to show any variation in diameter; when the truck and pistons were placed in it, they ran very smoothly from end to end, with a slight amount of friction. The cylinder was then mounted in a framework, and an hydraulic accumulator was connected with the space between the pistons, and the friction measured with various amounts of pressure in the oil. The first experiments were made with plain, smooth pistons, having a nominal clearance of about 0·002 inch, and the results were as unexpected in degree as they were unsatisfactory, and were roughly as follows :

For a pressure of 10 pounds per square inch or less, on the liquid, the friction was 1 to 2 pounds, but when the hydraulic pressure was increased to 60 pounds, the friction was increased to nearly 20 or 30 pounds; although, after the pistons were started in motion, the friction was greatly reduced, as long as they were kept moving. When the pressure was further increased to 225 pounds, it was necessary to use a hammer to start the piston at all, and after starting, the friction was some 40 or 50 pounds.

A long series of experiments was then made to determine the cause of this undue friction, and in making them it was found that the diameter of the cylinder varied, although the amount was so slight that it could not be found with a star gage. In order to ascertain at what points the diameter was smaller than the average, the pistons were placed at at certain point and the amount of leakage of oil by them, under a constant head, for a certain length of time was measured. They were moved 2 inches and the amount of leakage meausured at that point, and so on. In this way, some ieda could be obtained of where the cylinder needed more lapping.

This lapping was done by using a lead lap, rouge and oil, and then cleaning the cylinder very clean with gasolene; after this lapping had been done, pistons were made with various amounts of clearance and also with series of grooves, and it was found that the greater number of grooves the less the friction, but, unfortunately, the greater the leakage. No matter how closely the pistons were fitted, even if the difference in diameters was only 0·0002 inch or 0·0003 inch, when the pistons were at rest, the opening on one side would be greater than that on the other, which allowed the liquid under pressure to flow into the open side and hold the piston tightly against the opposite wall of the cylinder, preventing the flow of the liquid on that side, and so causing a large, unbalanced side load on the piston, which produced friction.

At times, by some good luck, when the pistons were moving, the liquid would completely surround them and they would move without any sticking, but these occasions were rare. To allow the liquid to surround the pistons a spiral groove was tried, and it was found that the friction became small and did not increase as the hydraulic pressure increased, so that the whole difficulty was very easily overcome by the simple expedient of cutting a fine spiral groove on the exterior of the pistons. This of course increased the leakage; but, as the groove is V-shaped, about 0·015 inch wide at the top and 0·01 inch deep, its section is very small. The diameter of the pistons is 2 $^{17}/_{32}$ inches and their length 2 inches; as the pitch of the grove is 0·1 inch, its length is 11 feet on each of the four pistons. The leakage through a pipe of this size and length is very small.

The main press also presented several difficult problems, the principal one being to get the two half-cylinders 20 (*see* figure 13), piston 17, piston rod 16 and the holes in the bushings 25 and 26 in the half-cylinders and the housing, all exactly in line and all so perfectly true that there would be very little friction, and, at the same time, very little leakage.

The hole in the housing was bored first, and then the housing planed to the boring, in order to get the sides perfectly parallel with the hole. The piston rod and sleeve 18 were finished by grinding and then lapped with a lead lap with both ground glass and crocus powder for several days, until it was reduced to the required size and to uniform diameter. The piston 17 was turned nearly to size, and then ground, but as the works was not provided with a grinding machine capable of grinding so large a diameter (16 $^1/_4$ inches) a grinding apparatus was rigged up on a lathe. When started, it was found that each tooth in the back gear caused a slight variation, which could be seen on the surface of the piston, after grinding. It was, therefore, necessary to rig up and turn the piston by hand on dead centers. The surface of this piston is also provided with a spiral groove to prevent sticking under pressure. This groove is in the form of a quadruple thread.

After rough turning, boring and drilling the half-cylinders, each was very carefully strapped on a face plate, the holes for the piston-rod bushing very carefully turned to size, the hole for the piston turned nearly to size, then ground, and finely lapped with a lead lap and ground glass until the piston would just drop in by its own weight. A false piston rod and a narrow cast-iron piston were then made, this piston being provided with a lead rim, which was charged with ground glass; the two half-cylinders were assembled with a false piston and piston rod in place, the cylinders placed on the table of a boring mill, and the piston rod fastened to the tool post. In this manner, the cylinders were very slightly lapped after being assembled.

The four bronze bushings were turned and were made force fits, but the holes in them were left slightly smaller than the piston rod. The first idea was to lap the holes in these four bushings after assembling them in place, but, after some experimenting, it was found to be impracticable to get satisfactory results in this way. The method finally used was as follows :

An end reamer was made, the hole in which very nicely fitted the small part of the piston rod, while its exterior was exactly the size of the large part of the piston rod. One of the bushings 25 was then forced into one of the half-cylinders and the two half cylinders assembled with the piston and piston rod, with the reamer in the cylinder, on the piston rod, between the piston and the bushing. The weight of the piston rod was carried in a sling, and the rod was such a good fit in the piston, and the piston in the cylinder, that by rotating the reamer on the rod, the bushing was reamed exactly to size and in line with the cylinder. The apparatus was then disassembled, the other inner bushing 25 forced into its place, the parts reassembled and this bushing reamed in the same manner. Then the two half-cylinders, piston, etc., were assembled with the housing 11, the reamer slipped into one of the bushings already finished, the outer bushing 26 on that side slipped into place, the piston rod inserted, and that bushing reamed. The last bushing was reamed in the same manner.

MISCELLANEOUS INFORMATION

[625 .216]

1. — Automatic railway couplings.

Figs. 1 to 15, pp. 1045 to 1048.

(*The Railway Gazette.*)

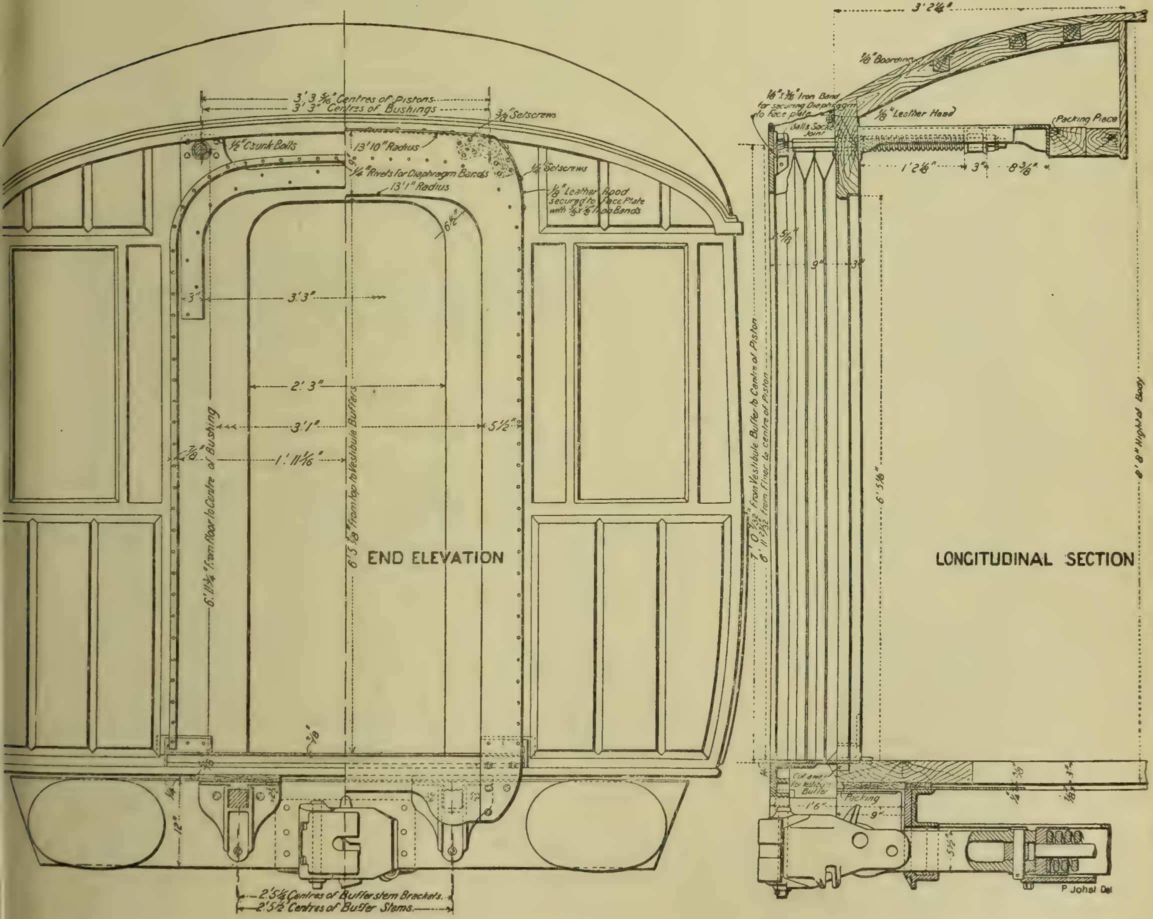
The day when automatic couplings will come into general use on British railways can hardly be a far distant one, and its arrival will mark a great and necessary forward step towards improving the equipment of railway rolling stock.

The value of such appliances has, of course, already been fully demonstrated in the United States and elsewhere, and their introduction in this country also can only be regarded as a matter of time.

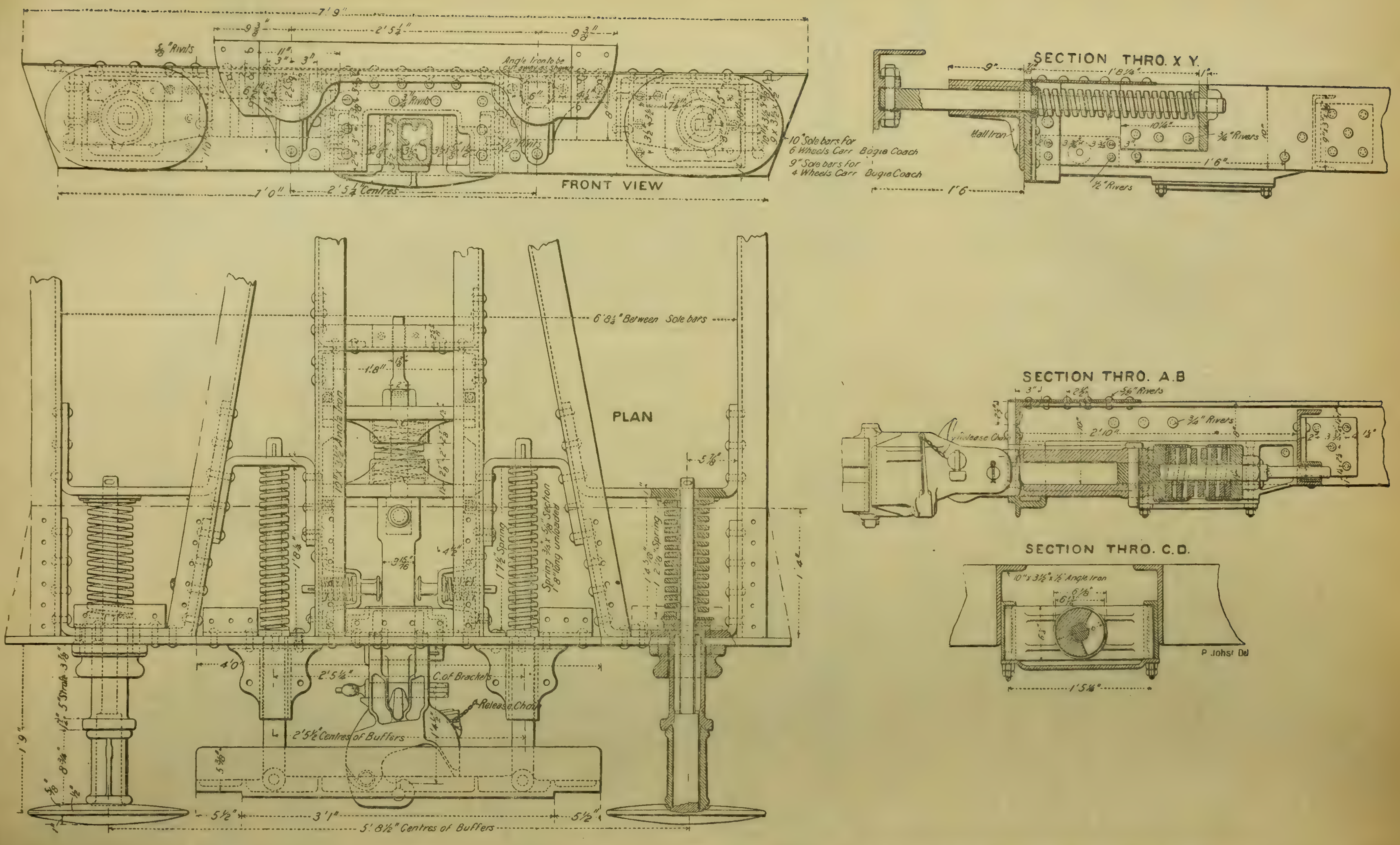
The duration of the period which must elapse before the substitution of automatic couplings for those of ordinary type has been finally carried into effect, as a standard measure, will largely be decided by the question of the expense involved in making the change, which, in view of the wide scope of the operations, must have a highly important bearing on the subject.

Moreover, as it would obviously be impossible for any railway company to alter the whole of its coaching and other rolling stock simultaneously, a means is required whereby the process of conversion may be carried out gradually and without interfering with the adaptability of vehicles already altered for use in conjunction with those still retaining the ordinary style of equipment.

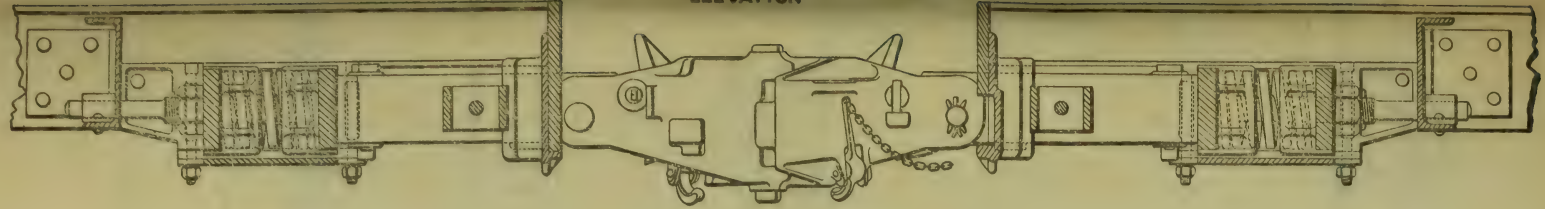
What is necessary, in other words, is a type of coupling which combines both automatic and non-automatic features so that during the transition period converted and new vehicles may, without difficulty, be employed in the make-up of any train as required. The accompanying drawings illustrate a coupling device in which such combined features are present, and for these we are indebted to the courtesy of Mr. W. S. Laycock of Victoria Works, Millhouses, Sheffield, the originator and manufacturer of the device. In this arrangement a cast steel vertical plane coupler head is pivotally attached to a special form of draw bar hook. When it is desired to use the non-automatic screw couplings, this coupler head is dropped down clear of the hook, the side buffer plungers being extended to their full limit, and the cast steel saddles attached to the buffer stems. The screw shackle is then connected up in the usual manner. When, on the other hand, the automatic coupling is to be used, the coupler head is brought into the horizontal position and there securely held by inserting a pin in the locking hole provided for the purpose. At the same time, the detachable sleeves must be removed from the buffer stems on the side buffers and the buffer plungers pushed back out of action. No springs are employed for actuating any part of the mechanism. The knuckle is held in the engaging position by means of a vertical gravity lock, and the coupling is released by pulling a chain, one end of which is attached to the lock lifting lever and the other end to the headstock or side of the carriage, as shown in the drawings. No necessity whatever exists for a shunter to go in between the carriages to perform the operation of uncoupling. Tests carried out on the Great Northern Railway with these couplings have shown conclusively that the act of converting the automatic coupling into a non-automatic one, or *vice versâ*, can easily be accomplished by one man in less than a minute.


3' 3 5/16" Centres of Pistons
3' 3" Centres of Bushings
3/8" Setscrews
1/2" C'sunk Bolts
13' 10" Radius
1/4" Rivets for Diaphragm Bands
13' 1" Radius
1/4" Setscrews
1/8" Leather Hood secured to Face Plate with 1/8 x 1/8 Iron Bands
6 1/2"
3"
3' 3"
2' 3"
3' 1"
5 1/2"
7/8"
1' 11 1/16"
6' 11 1/4" from floor to Centre of Bushing
6' 5 1/8" from top to Vestibule Buffers
END ELEVATION
12"
2' 5 1/4" Centres of Bufferstem Brackets
2' 5 1/2" Centres of Buffer Stems
3' 2 1/4"
1/8" Boarding
1/8" x 1 1/8" Iron Band for securing Diaphragm to Face plate
Ball & Socket Joint
1/8" Leather Head
Packing Piece
1' 2 1/8"
3"
8 3/8"
5/8"
9"
3"
7' 0 1/32" from Vestibule Buffer to Centre of Piston
6' 11 23/32" from Floor to centre of Piston
6' 5 1/8"
8' 8" Highest Body
LONGITUDINAL SECTION
Cut away for Vestibule Buffer
Packing
1' 6"
9"
5 1/2"
P Johst Del

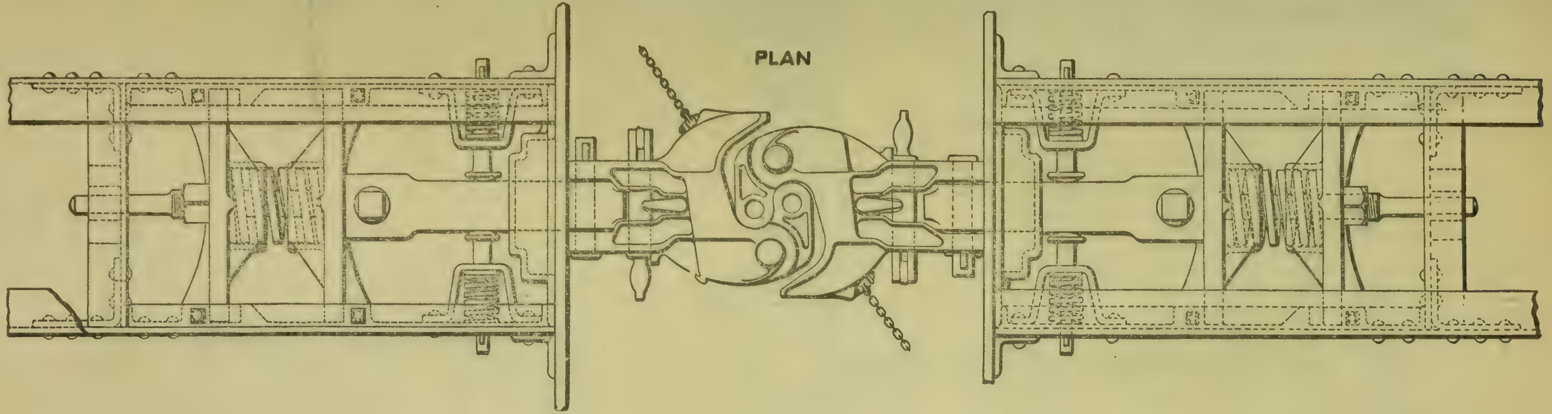
Figs. 1 and 2. — End elevation and longitudinal section of vestibule as fitted on Great Northern Railway.



Figs. 3 to 7. — Plan of underframe showing automatic coupler, draft gear and adjustable side buffers as fitted on Great Northern Railway.

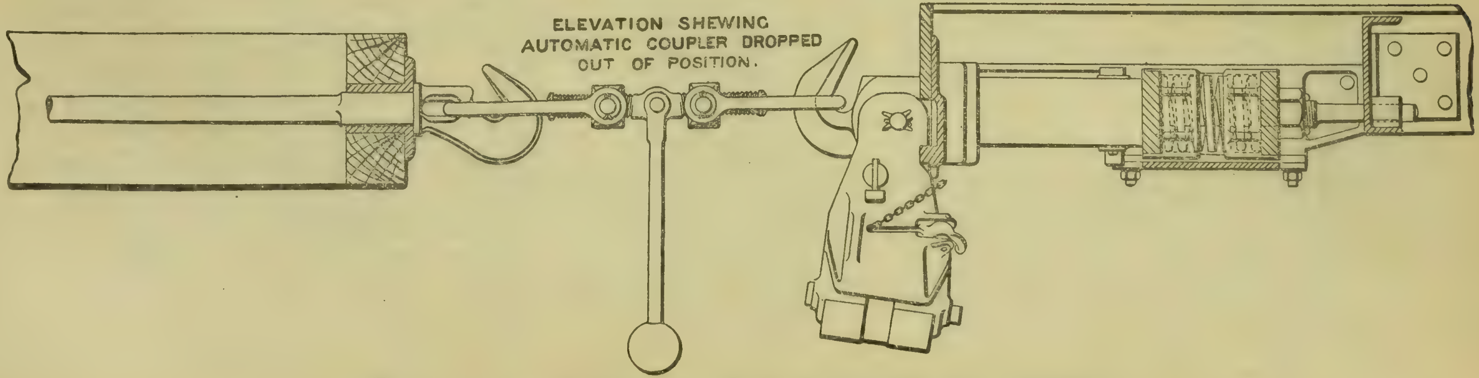


ELEVATION

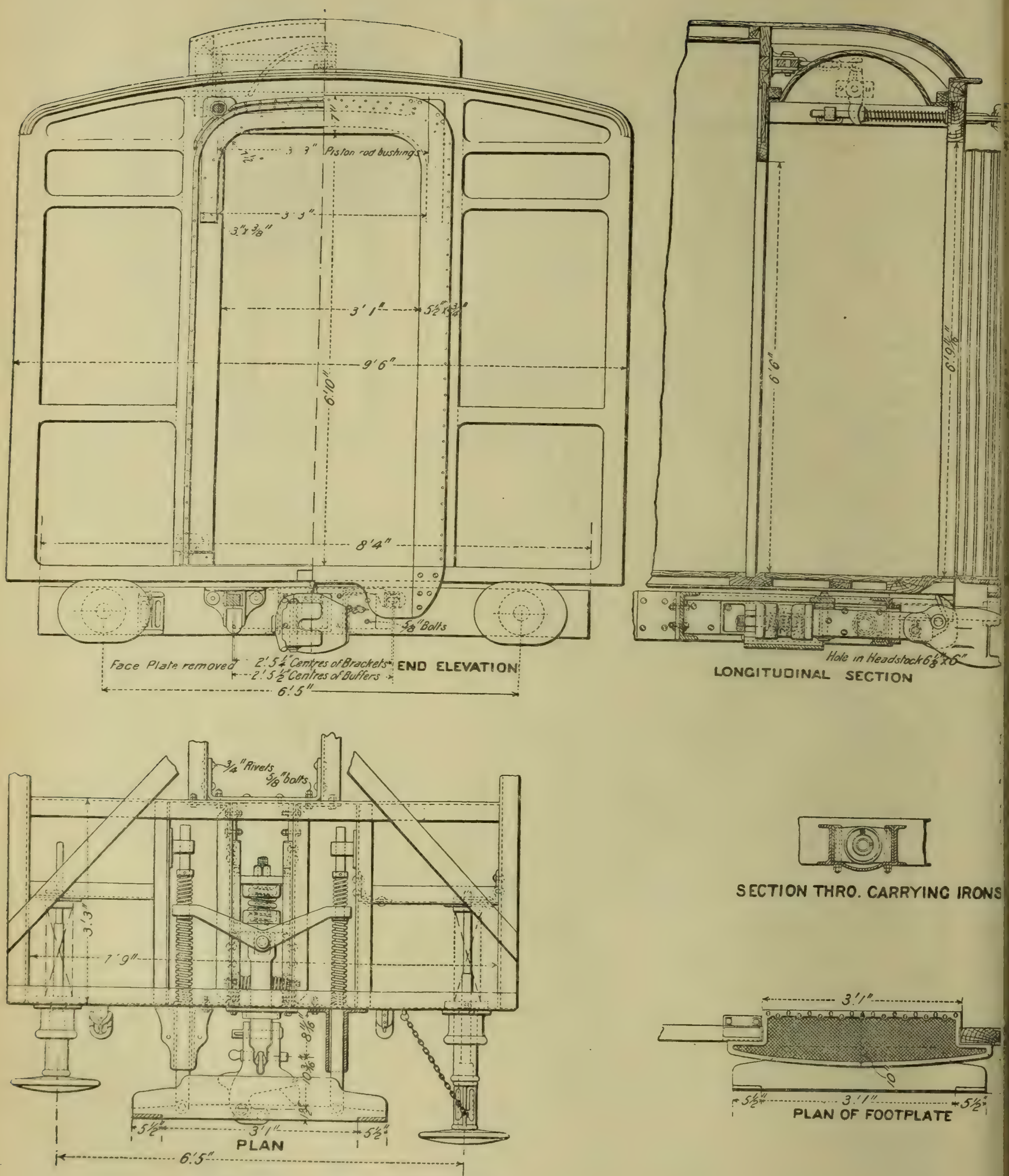


PLAN

ELEVATION SHEWING AUTOMATIC COUPLER DROPPED OUT OF POSITION.



Figs. 8 to 10. — Three views illustrating the combination automatic coupler.



Figs. 11 to 15. — General arrangement of vestibule and automatic coupler as fitted on the Great Indian Peninsula Railway.

The drawings show the device to be exceedingly simple in construction, and the foregoing brief description of the operative methods will have made it clear that the same characteristic applies to them also. In designing the arrangement, Mr. Laycock took as a basis the standard automatic coupling of the American Master Car Builders' Association, and he has, beyond question, succeeded in adapting the principle of that device to the needs of the railways of this country. The arrangement illustrated is in use on the Great Northern, North-Eastern and North Bristish Railways as part of the equipment of the East Coast Joint Stock, which possesses a deservedly high character for all-round comfort and efficiency. It is also employed by the Great Central Railway Company, and by certain of the Colonial and Indian Railways, and is proving highly successful wherever used.

The railway carriage vestibule, devised by Mr. Laycock and constructed at the works at Sheffield, has many advantages over some others in use. An equalising beam is fitted to the coupler and centre buffer, and the spring plungers at the top of the vestibule have a compound compensating arrangement which distributes the pressure equally over the whole vestibule. This greatly assists matters when traversing curves and is generally found to be advantageous in use.

When the vehicles are coupled, the springs of the centre buffers are closed so as to give an initial compression of 1 $^1/_2$ inch, and the equalising beam which pivots on the hook shank is formed with an oval eye at each end through which the buffer stems, also oval in shape, for a distance of 1 $^1/_2$ inch in front of the eyes to the tail end, pass, being then attached to the guide brackets on the longitudinals.

The forward portion of the buffer stem is of round section, and on each stem are two springs so that when the car is running round curves — at which times the pressure is transmitted to one spring more than the other — the round portion of the buffer stem, not being able to pass through the oval eye, is brought up against the equalizing bar and as the latter is, as before stated, pivoted in the middle, the pressure is conveyed to the spring on the opposite side.

The bellows portion of the vestibule, known as the diaphragm, is made either of plated rubber or canvas; its two corresponding parts each terminate in a wide-faced solid steel frame. The two bellows are extended by means of two powerful springs which bring the face-plates together and hold them securely in position.

This form of vestibule has great advantages when considered in itself as a buffer. In case of accident, the danger of telescoping is reduced to a minimum as the vestibule extends from the platform to the roof of the car, and as the face-plates on the end of each bellows provide a large surface for contact, the likelihood of the underframe of one car riding over that of the one next to it becomes remote, and the wheels are much less prone to leave the rails.

The platforms between the cars are of cast steel, and in the event ot two cars being brought violently in contact with one another, the blow on the underframes is taken by the platforms, and the damage to the underframes themselves is thereby greatly reduced.

The Laycock vestibule is used on the joint rolling stock of the East Coast Companies, also on the Great Central, Great Indian Peninsula, Rhodesian, Central South African and other railways.

[621 .33 (.42)]

2. — Applications of electricity on English railways.

(*Zeitung des Vereins.*)

Much detailed information is to be found in the *Electrician's Electrical Trades Directory and Handbook for 1907*, which appeared early in March of this year. Several tables are again given dealing with the applications of electricity on English railways. The tables of the previous years have been discussed several times in the *Zeitung* (1902, Nr. 35; 1904, Nr. 58; 1906, Nr. 38); if successive years are compared, not only is fairly accurate information obtained as to the progress and development of the applications of electricity on English railways, but also several valuable deductions may be drawn of more general application.

Table I shows that during last year, the length of track equipped with electrically interlocked block signals again increased by a little over 6 per cent, but that the total length of such track is hardly yet equal to $^1/_{20}$ of the length of track on which non-interlocked or staff signals are in use. The total number of the electrical instruments used for signals and communications (telephones, telegraphs, block signals, block signal instruments, indicators, staffs, etc.) has increased by 5·8 per cent; but telephones taken by themselves increased by more than 15 per cent, and the purely electric block signals have more than doubled in number. The increase in the corresponding electrical conducting wires is a little greater than 13 per cent, but for the first time it is, curiously enough, accompanied by a reduction in the length of the railway telegraph wires used for telegrams only. Comparison with the tables of previous years, shows that a little less than half of the reduction shown is the result of a clerical or printer's error in extracting from the original authority, and of the resulting error in the subsequent calculation; but the greater half of it is a real reduction, and is due to the fact that on sundry lines, when the State acquired the telegraph system, there were wires which had less and less to do and became unnecessary, and finally became the property of the State; then also some of the wires were converted to other uses, principally in connection with telephones. Telephones still continue to show a remarkable increase; the increase between 1901 and 1903 was 850, and between 1903 and 1905 it was 4,560. Between the end of 1905 and the beginning of 1907, that is in one year, the increase was 3,936; there are now 28,856 telephone offices.

Another noteworthy increase in electric signals, which only appears recorded in table I as far as the Caledonian and Great Eastern are concerned, arises from the Westinghouse installations for operating switches, etc., by power on these two railways, and from the equipment of the London metropolitan and tube railways with Westinghouse block signals. Details given in table II show that in the beginning of 1907 there were altogether 2,301 signals operated by pneumatic power, controlled electrically; 56·6 per cent of these are automatic block signals in connection with the track circuits.

Electric lighting arrangements on English railways generally show a very great increase; the figures are given in table III. During last year, the number of arc lamps increased by more than 66 per cent and that of glow lamps nearly 10 per cent; the number of carriages equipped with the electric light increased 35·5 per cent. If we compare these different increases, we at once find that although the progress in the electric lighting of carriages is considerable, it is by no means equal to the progress in the electric lighting of stations and yards. A similar proportion existed up to 1903; but the converse was the case between 1903 and 1905, when many new carriages equipped with the electric light were built or purchased. This extraordinary development in electric lighting is naturally attended with a correspondingly large increase (shown in the

Table I.

RAILWAY.	Length of track equipped with electrically interlocked block signals.	Number of block signals operated electrically.	Number of telephones used in the signalling service.	Total number of all electrical instruments (telegraphs and block signals).	Length of conducting wires	
					for railway purposes generally.	for telegrams only.
1	2	3	4	5	6	7
	Kilometer. (Miles.)				Kilometer. (Miles.)	Kilometer. (Miles.)
Barry	...	...	110	122	434 (270)	4 (2)
Caledonian	40·2 (25·0)	...	2,734	16,740	12,558 (7,803)	8,145 (5,061)
Cheshire Lines	2 (1·2)	...	298	1,861	1,994 (1,239)	1,167 (725)
Glasgow & South Western	6·5 (4·0)	123	359	1,620	2,918 (1,813)	3,033 (1,885)
Great Central	36 (22·4)	...	1,326	8,603	8,357 (5,193)	2,069 (1,286)
Great Eastern	282·5 (175·5)	100	976	14,856	11,390 (7,078)	7,942 (4,935)
Great Northern	3·8 (2·4)	11	958	11,011	12,682 (7,880)	6,634 (4,122)
Great Western	21·7 (13·5)	2	4,055	29,501	30,432 (18,910)	21,350 (13,267)
Highland	...	...	350	510	2,646 (1.644)	3,113 (1,934)
Lancashire & Yorkshire	...	18	2,363	9,686	9,750 (6,058)	3,611 (2,244)
London, Brighton & South Coast	154·5 (96·0)	200	779	3,980	5,554 (3,451)	4,128 (2,565)
London & North Western	...	...	3,200	21,600	27,192 (16,897)	12,863 (7,993)
London & South Western	633 (393·3)	146	1,492	21,522	12,495 (7,764)	13,912 (8,645)
London, Tilbury & Southern	8 (5·0)	...	104	467	1,127 (700)	1,703 (1,058)
Midland	55·5 (34·5)	1	3,547	23,075	22,722 (14,119)	26,133 (16,239)
North British	8·8 (5·5)	...	1,050	6,544	12,527 (7,784)	6,117 (3,801)
North Eastern	...	...	2,978	17,755	19,796 (12,301)	5,770 (3,585)
Nord Staffordshire	...	...	595	2,038	1,645 (1,022)	700 (435)
South Eastern & Chatham	702 (436·2)	55	1,016	8,281	8,148 (5,063)	8,547 (5,311)
Taff Vale	...	...	373	295	1,820 (1,131)	226 (140)
Great Northern (Ireland)	...	...	161	242	2,152 (1,337)	5,277 (3,279)
Midland Great Western (Ireland)	...	...	32	401	1,878 (1,167)	3,558 (2,211)
Total, beginning of 1907	1,954·5 (1,214·5)	675	28,856	200,110	211,217 (131,247)	146,063 (90,761)
Total, end of 1905	1,834·8 (1,140·1)	320	24,920	189,452	195,266 (121,335)	149,454 (92,868)
Increase	119·7 (74·4)	355	3,936	10,658	15,951 (9,912)	— 3,391 (— 2,107)

Table II.

RAILWAY.		Power installations.	Switches.	Signals	
				non-automatic.	automatic.
Caledonian		1	127	189	...
Great Eastern		1	43	25	...
Lancashire & Yorkshire		1	43	126	...
North Eastern		12	399	742	...
London metropolitan and tube railways.	Charing Cross-Euston & Hampstead	6	27	35	119
	Baker Street & Waterloo	5	15	32	86
	Great Northern & City	...	...	...	4
	Great Northern, Piccadilly & Brompton	5	18	37	135
	Metropolitan District	13	191	283	488
Total Westinghouse appliances		44	863	1,469	832

Table III.

RAILWAY.	Number of electric lamps in use.		Carriages and vans equipped with electric light.		Horse-power of generating stations.
	Arc lamps.	16 candle-power glow lamps.	Number.	System.	
Barry	145	3,750	128	Stone.	75
Caledonian.	974	12,700	146	140 Stone, 6 Vickers-Maxim.	1,200
Cheshire Lines	262	965	46	Stone.	...
Glasgow & South Western	185	5,050	6	Stone.	40
Great Central.	1,478	12,180	333	315 Stone, 17 Lucas-Leitner, 1 Vickers-Maxim.	1,447
Great Eastern	490	11,921	37	36 Stone, 1 with accumulators.	152
Great Northern	1,064	14,631	107	88 Radcliffe, 19 Stone.	1,909
Great Northern (Ireland).	84	529	231	Stone.	750
Great South & Western (Ireland).	57	15	21	Stone.	...
Great Western	252	12,149	71	28 Stone, 39 Lucas-Leitner, 1 Vickers, 1 Moskowitz, 1 Siemens, 1 Beaumont & Still.	...
Lancashire & Yorkshire	822	12,735	213	Stone.	4,212
London, Tilbury & Southend	197	190	432	Stone.	...
London, Brighton & South Coast	397	2,936	653	473 Stone, 180 Stroudley & Houghton.	669
London & North Western	1,515	30,000	830	Stone.	5,075
London & South Western	969	18,270	1,029	988 Stone, 41 Vickers-Maxim.	9,726
Midland	2,032	18,987	251	52 Stone, 18 Vickers-Maxim, 181 Verity-Dalziel.	4,118
Midland Great Western (Ireland).	10	300	100	8 Stone, 82 with accumulators.	50
North British.	951	8,910	66	Stone.	972
North Eastern	2,065	24,576	202	2 Selbstfahrer, 97 Moskowitz, 102 with accumulators.	25,219
North Staffordshire.	122	2,299	236	Stone.	29
South Eastern & Chatham	369	3,570	1,950	Stone.	369
Taff-Vale	40	650	...	...	...
Total, beginning of 1907.	14,480	197,313	7,088	...	56.012
Total, end of 1905.	8,715	101,773	5,309	...	13,768
Increase.	5,765	95,540	1,779	...	42,244

last column of table III) in the horse-power used on the English railways for generating current; the figures show that the English railways, in view of their largely increased requirements, are trying to become more and more independent of outside supplies of current.

Table IV.

CARRIAGE-LIGHTING SYSTEM.	Number of carriages equipped up to			
	1901.	1903.	1905.	1907.
Ordinary accumulator batteries	1	95	93	197
Vickers-Maxim	4	56	61	67
Radcliffe	88	88	88	88
Stroudley & Houghton	271	260	220	180
Carswell	291	...	...	...
Lucas-Leitner	...	...	42	56
Moskowitz	...	...	...	99
Siemens	...	...	...	1
Beaumont & Still	...	...	...	1
Verity-Dalziel	...	...	...	181
Stone	3,016	4,362	4,805	6,219
Total.	3,671	4,861	5,309	7,088

As regards the electric lighting of carriages on the English main lines, table IV shows that several new systems are being tried; of these the Moskowitz and Verity-Dalziel systems would appear to be in favour. Generally speaking, the system of each carriage being equipped with its own generating plant has for a long time been the predominant one; this is again confirmed by the fact that 87·7 per cent of these carriages are equipped on the Stone system. It may however be worth noticing that the Stone system has lost during the past year a little more than 2 per cent of its former predominance over its younger rivals.

[621 .132.5]

3. — Italian Prairie balanced-compound locomotives, and their future,

By Charles R. KING, Bristol, England.

Figs. 16 to 21, pp. 1055 and 1056.

(*Railway Machinery.*)

The locomotive here illustrated is the first four-cylinder locomotive that has been designed under the new *régime* of the State Railways of Italy. The first specimen has just been delivered to the State Railways in the presence of the director-general of Italian Railways and a special delegation.

The engine proper is of the Plancher compound system, notable for having only one valve for one pair of cylinders, and each high-pressure and low-pressure valve independently variable in length of travel. Hitherto the relative cut-off for each group of cylinders has not been variable from the foot-plate. In the Prairie type engines there are two reach-rods, permitting the two valve-mechanisms to be operated independently. It remains to be seen whether, in this particular case, the duplicate reversing will be maintained permanently; in the general run of practice on the European continent, duplicate reversing gears are abandoned as soon as a proper ratio has been ascertained for the percentages of expansion in the two groups of cylinders. As, however, the grades to be worked by the new vary greatly, it is not certain that a fixed ratio will be economical.

This new locomotive is especially worthy of attention for its general design, which is radical. It is an extraordinarily supple machine considered as a carriage. The driving-wheel springs are equalized with the trailing-wheel springs. The front connected-wheel spring is set transversely, so that the engine frame is only supported in the center line. The pony-truck is carried on swing-links, the lateral control being effected by pairs of volute springs. A very small amount of lateral play is also allowed at the other end of the engine, in the trailing axle-boxes. Every axle-box, from end to end of the engine, is fitted with rotating liners of Zara's patent (fig. 17), so that in entering or leaving curves, or whenever the axles momentarily assume a position out of square (vertically) with the frames, the rotating liners permit all such movements, contrary to the usual action of axle-boxes, which, in resisting the movements, set up injurious strains that ultimately fracture the fatigued portions. That there is real utility in articulated axle-boxes may be assumed from the fact that, in the first three years of their introduction, over 2,000 Zara baxes were in use. (See *Railway Machinery,* October, 1906.)

The interesting feature of the pilot truck consists in the application of a swinging pivot to the arrangement of conjugated axles usual with the pony truck, introduced some years ago by Mr. Helmholtz of the firm of Krauss in Munich, Bavaria, so that the frame of the truck is no longer connected to the leading axle through a rigid fulcrum, as in Krauss, but through a center which is displaced in such manner as to allow the first pair of driving wheels to be displaced laterally to the inside of the curve, according to the guiding of the front or advancing flange of the leading outside driving wheel; whereas, with a rigid pivot as in the Krauss conjugated system, the leading flange of the front outside driving wheel is necessarily jammed hard against the outside rail. See line cuts, figures 18 and 19.

In regular service, the Krauss conjugated truck proved to be so safe that it was admitetd on the railways of Germany for the fastest interurban trains for which a four-wheeled pilot truck had before been obligatory. The Italian express engine is built for speeds of 62 miles per hour, but, in the preliminary runs it made before being sent to Firenze (Florence) for its dynamometer tests, it was run at speeds of 66 miles per hour. This was in February, on the line to Chiasso (Switzerland) and to Piacenza. The truck had already been tested in previous Italian locomotives and upon the electric locomotives shown in *Railway Machinery* issue of February, 1907, both of which electric locomotives are from the drawings of the designer of the locomotive under mention. Much attention has been given in the technical press to these Simplon locomotors, all ignoring this novel

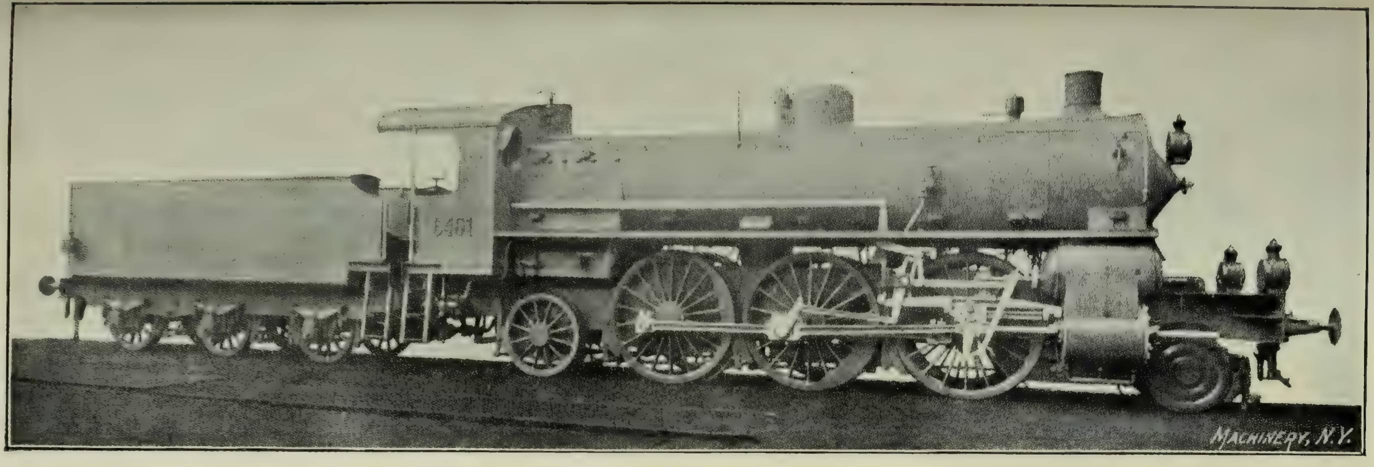


Fig. 16. — Italian Prairie balanced-compound locomotive.

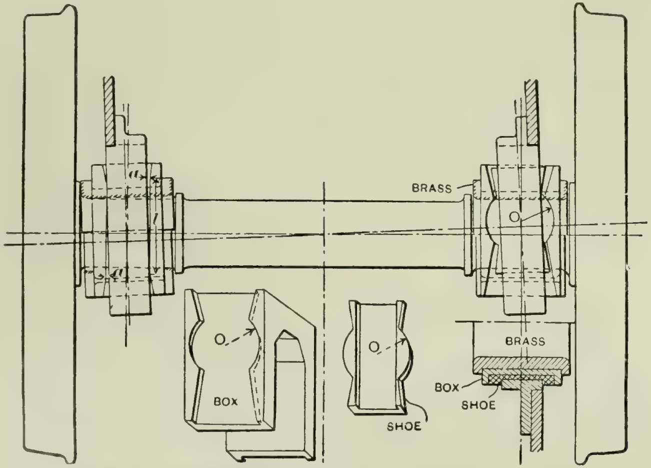


Fig. 17. — Construction of axle-boxes, Zara's patent.

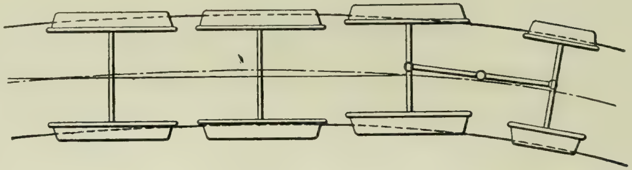


Fig. 18. — Truck connected to leading axle through rigid fulcrum.

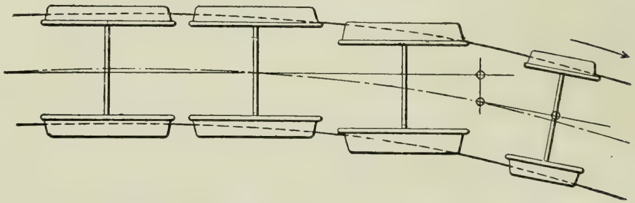


Fig. 19. — Truck connected to leading axle through a swinging pivot.

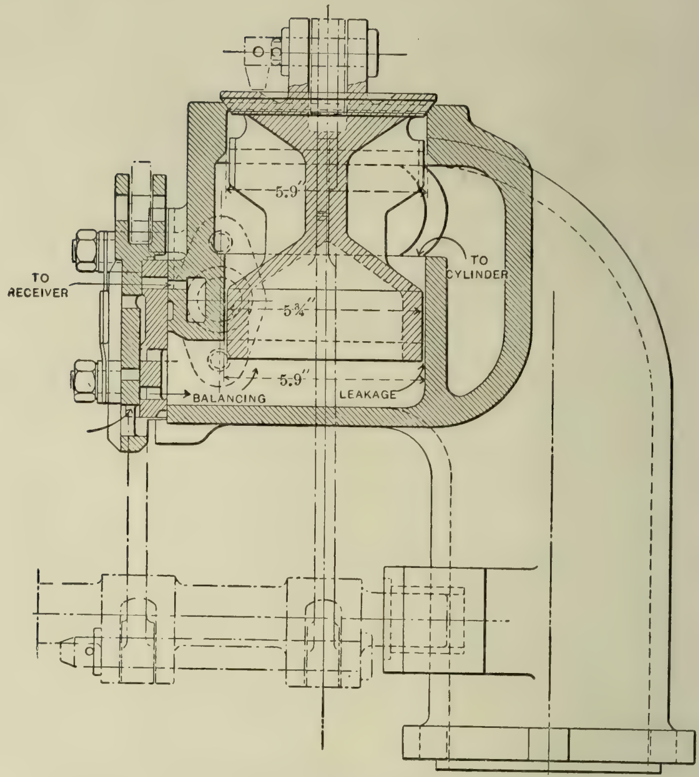


Fig. 20. — Section through the Zara steam throttle valve.

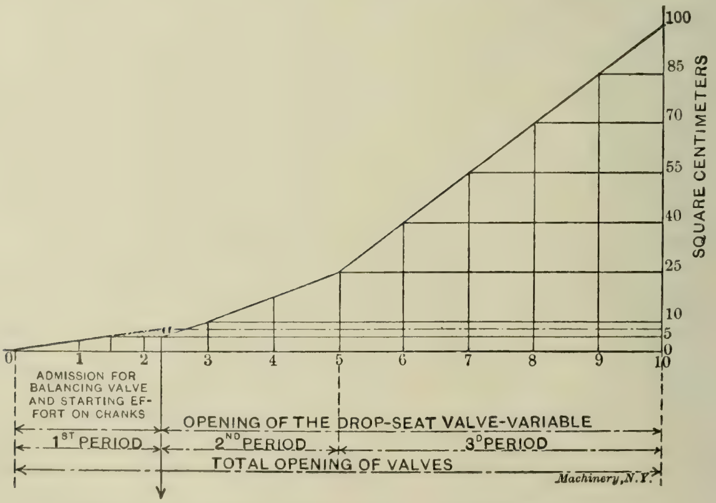


Fig. 21. — Diagram of inlet openings of the Zara valve.

truck fitted at their two extremities, and also the fact that they were schemed by a railway engineer of life-long experience; the motors they carry presenting little of interest to railway engineers. It was while Signor Zara was designing these Prairie electric locomotives in collaboration with the locomotive engineers of the works of the Hungarian State Railroads at Budapest, in June, 1903, that the writer heard him state his reasons for adopting the conjugated pilot-truck in these locomotors, which have many points in common with his new locomotives.

This and the subsequent digression may perhaps be excused, as they show that in Italy, as elsewhere, machines for railways must be designed by those who have made railways their lifelong study. It is most possible, however, that after several more attempts at electrical traction with the same uneconomical results as the chief Italian venture in this direction (that is, the electrified line from Milano to its northern suburbs) Italy will replace electricity with self-propelled steam trains. Of this change, there has long been question in regard to the line just mentioned, despite the news periodically circulated in the foreign press since the year 1902, in the stereotyped phrase : " All the steam railways of Northern Italy will soon be electrified." The real fact is that the steam locomotive has been wrought to a high state of perfection in Italy, and its superior economy enables the State to handle traffic at lower cost by this means than by hydro-electric or steam-electric plants, which have proved to be the reverse of economical, while they introduce an intolerable complication in trunk-line traffic. This fact is already exemplified in the daily working of the Simplon tunnel, where all the international express trains are obliged to stop twice in the space of 13 miles, at out-of-the-way insignificant villages, in order to allow the electric locomotives to be coupled on. The result is comparable to the slow services of city suburban trains, with no advantage for the passengers or trainmen as regards the aeration of the tunnel; for, with steam locomotives working the trains, the most fastidious of persons could have complained of no discomfort that is not equally present with the electric locomotives, and the locomotive enginemen expressed their satisfaction with the purity of the tunnel air, and of the immaterial influence of any emanation of the locomotives upon the atmosphere.

The trouble that was apprehended from locomotives was not, in fact, realized in practice; but the advantae derived from the use of electric current was that of obtaining traction practically free of cost for motive power in the tunnel, since the power plant was there, already installed for the boring work of the tunnel. None the less, the Federal Railways agreed to the electrification on condition that the electric company should hand bach the tunnel in right order for steam-motor working, and without claim for compensation, if electrical train operation gave rise to inconveniences; but, so far, nothing similar to the New York experience with this form of traction has occurred. Thus it will be understood that steam locomotives are more likely to replace electrical traction than otberwise in Italy, notwithstanding that 36,350,000 lire (£7,270,000) have been voted for the electrical equipment of a few short lines. The locomotive illustrated has a greater tractive effort, a higher speed-capacity and, when empty, weighs no more than the Prairie type electromotors of the same designer.

It will be noticed that in these Prairie engines, the absolutely rigid wheel base is confined to the driving and rear connected wheels. The connecting side-rods work on spherical pins of the forward or conjugated wheels, in order to avoid strains on the brasses.

The boiler is representative of the latest Italian practice, although the construction is not so advanced as is that of the new Austrian Prairie locomotive. In this latter, gussets are used exclusively for staying the back sheet of the firebox, while in the Italian boilers a couple of horizontal plate stays are employed according to the general practice of the Continent. It is a singular fact that the American practice in locomotive boiler construction, is usually first followed in Europe by Austrian and Bavarian designers.

The throttle of the Italian engine has a three-phase action on the steam. This throttle-valve, patented by the actual designer of the locomotive described, Signor G. Zara, has been the subject of recent comment in the engineering press, because the manager of the Hunslet Engine Company, of Leeds, England, attributed to it the same principle as another throttle which had been made by this firm for some years past, and the idea and principle of which had been suggested by a sketch in an old number of the *Scientific American.* The drawings published with the communication of the Hunslet firm showed that, mechanically, their valve differed from the Zara valve in only one small detail — this detail constituting a vital difference in the principle of working of the two valves. The unique feature of the Zara valve applied to the locomotive illustrated, is its three phases of admission due to the graduated openings given by the various parts of the valve. This will be understood from the detail drawing, figure 20. Here the lower or piston valve is shown to be a loose fit in the cylindrical part of the head, the piston measuring 5 $^3/_4$ inches and the bore 5·9 inches. This gives an annular opening of constant section through which the steam flows to the cylinders as soon as admitted to them by means of the balancing or pilot valve, thus applying pressure on the engine pistons without slipping the wheels. This action of the steam is termed the first period or phase. The Hunslet-American valve appears to narrowly miss this pre-admission of steam, for its pilot valve, although allowed a clearance and lift of $^1/_{16}$ inch below the closely-fitting perforated lower cylindrical valve, closes these perforations when steam is introduced below the balancing piston. The advantages to be derived from mechanically-graduated throttle admission appear to be considered of importance in Europe, where the Zara valve has been adopted by a large number of Continental railways both for saturated and superheated steam. The diagram, figure 21, represents the sectional openings, in square centimeters, as given by various positions of the three-phase throttle valve.

The auxiliary or double-ported valve, visible in the drawing of the throttle, admits live steam to the receiver only whenever the main valve is in the first period of its opening, and also only when the engine is in full gear. This latter is controlled by means of a miniature slide valve on the extension-rod of the high-pressure valve, so that live steam is only admitted when the engine is starting with a heavy load. The operation is automatic, and the working of the engine is as simple as a two-cylinder single expansion locomotive.

The engine is particularly well balanced in its motor efforts. The cranks are keyed, as usual, at 180 degrees, the cylinders are set all in one transverse plane, and the pressure exerted on each pair of high-pressure and low-pressure cranks is absolutely equalized by the constant intercommunication of the opposite ends of the same group of cylinders. Thus the opposing efforts on each set of cranks are perfectly equilibrated, and the balancing of the rotating masses is effected with a minimum value for the wheel counterweights, thus contributing notably to the even running of the machine and to the preservation of the track. In these engines there are, of course, only one-half the number of exhausts usual with four valves having four periods. The force of the blast is regulated by means of a variable nozzle having a central cone or plug with projecting helical wings, similar to those nozzles of the "Nord" and Paris-Lyon railways of France.

The boiler is of steel; the barrel is formed of three rings having double-welt strips and six rows of rivets closing the longitudinal seams. The inside firebox is of copper, and the lower contour of the boiler barrel is welted with 0·078 inch sheet copper to preserve it from corrosion. Steel tubes having proved unsatisfactory, from their rapid pitting and sloughing with the water used, all tubes are now of brass and the ferrules of copper. Special rests on the mud-ring support the boiler on the dilation brackets behind, and the intermediate supports are, as in American practice, of thin vertical plates allowing expansion movements of the boiler.

DIMENSIONS.

Cylinders:	
High-pressure	14 $^{1}/_{4}$ inches.
Low-pressure	23 $^{1}/_{4}$ —
Piston-stroke	25 $^{1}/_{8}$ —
Boiler-pressure	215 pounds.
Driving wheels diameter	72 $^{3}/_{4}$ inches.
Heating surface, total	2,539·3 square feet.
Grate area	37·6 — —
Weight:	
Engine empty	61·5 metric tons.
— loaded	68·5 — —
— maximum adhesion	43·5 — —
Total wheel-base	27 ft. 8 $^{3}/_{4}$ in.
Driving wheel-base (flexible)	12 ft. 11 $^{1}/_{2}$ in.
Bearing wheels, diameter	37 $^{5}/_{8}$ inches.

[625 .232]

4. — Invalid and family compartment cars for the London & North Western.

Figs. 22 to 25, pp. 1061 and 1062.

(*Railway Age.*)

The London & North Western Railway of England has just completed two new invalid and family compartment cars, which are 50 feet long by 9 feet wide. One of the illustrations shows a general outside view of the car, and the other views give a good idea of the internal arrangement. These cars were built at the railway company's carriage works at Wolverton, after the plans of C. A. Park, carriage superintendent, and were specially designed for the comfort of invalids when traveling.

The following are the outside dimensions of the car body: length, 50 feet; width, 9 feet; height at center, 8 ft. 5 in.; height at side cornice, 6 ft. 7 $^{3}/_{4}$ in.

When mounted on the underframe the dimensions are: length over buffers, 54 feet; height at center above rail, 12 ft. 5 $^{1}/_{2}$ in.

The wheel base of the 4-wheel trucks is 8 feet, and the trucks are 35 ft. 6 in. between centers.

The underframes and trucks are of standard pattern, the former being made of rolled steel channels. The truck sides are of deep angle steel, with channel steel longitudinals and transoms, and steel bolsters, which carry spiral springs for supporting the underframe and carriage body. The structural framing of the cars is principally teak and oak, the outside being paneled with canvased and blocked Honduras mahogany. The exterior is painted the company's standard colors, lake for the bottom panels and French white for the upper, and the moldings lined in gold.

The internal arrangement is shown on the plan. The invalid compartment is nearly in the center of the car and is 18 ft. 6 in. long by 8 ft. 2 in. wide. It is fitted with an ornamental gold lacquered brass bedstead, which has a box mattress with a hair mattress on top. At the foot of the bedstead are two easy chairs trimmed with green Blenheim moquette to match the couch opposite the bed. The couch is of good dimensions to enable an invalid to recline on it when desired. There are only two easy chairs at present, but more can be provided if desired when the car is being used as a family compartment.

On either side of the saloon, at one end of the invalid compartment, double folding doors are provided, wide enough to lift a Bath chair through without disturbing the occupant. The chair can then be taken with ease up to the side of the bed and couch, and an invalid transferred into either.

At the head of the curtains are hung from a brass curtain rod to screen the bed from any draft from that end of the compartment. These curtains are in green tapestry and can be fastened together at the center or drawn to the side. At the opposite end of the compartment a silvered lavotory wash basin with all requisites is provided. This is in cabinet form, and is supplied with hot and cold water from the tanks in the adjacent lavatory.

The finishing of the side and end walls is in framed American walnut, with sycamore panels secured with bilection moldings. The squab panels between the large and small drop lights, and the dado to the top of the skirting, are upholstered in Saladin moquette, except the end dado at the double entrance doors, which is filled in with Italian walnut. The floor is covered with a thick Wilton pile carpet to harmonize wilh the rest of the upholstery. This is laid on thick gray felt, which also serves to deaden the sound and vibration, thus making the compartment very quiet when the car is running.

The elliptical ceiling is paneled out in figured lincrusta laid on indurated millboard. It is finished in white enamel picked out on the borders and cross bandings with a gold floral design.

The two first-class compartments, at opposite ends of the saloons, both leading out of the large compartment, are of the same dimensions, 7 ft. 6 in. long and 8 ft. 2 in. wide finished. Four American walnut-framed chairs, upholstered in Saladin moquette, are arranged to draw out to meet at the center, forming a bed when required.

The walls are framed in American walnut and sycamore panels, with glazed photographic views fixed in with charrier bilection moldings, and with net rod brackets for small articles over the backs of the seats. The ceilings are paneled out in lincrusta, enameled white and relieved at the borders and cross bands with a gold floral design. The floors are covered a thick Wilton pile carpet laid on thick gray felt.

At one end of the car a large luggage compartment for personal luggage is provided. This compartment is 7 ft. 7 1/2 in. long by 8 ft. 2 in. wide. The walls are cased with V-jointed slats, painted and grained, and the roof is painted white. Hat and coat hooks are provided.

The blinds throughout these cars are of Holbein gold tapestry, mounted in blind hoods, and are adjustable. The cars are electrically lighted on Stone's system by lights in the roof. The lights have opal and tinted glass shades, and are controlled by switches in the compartments. In the invalid compartment a special " dimming " switch is fitted to dull the center lights to any desired extent.

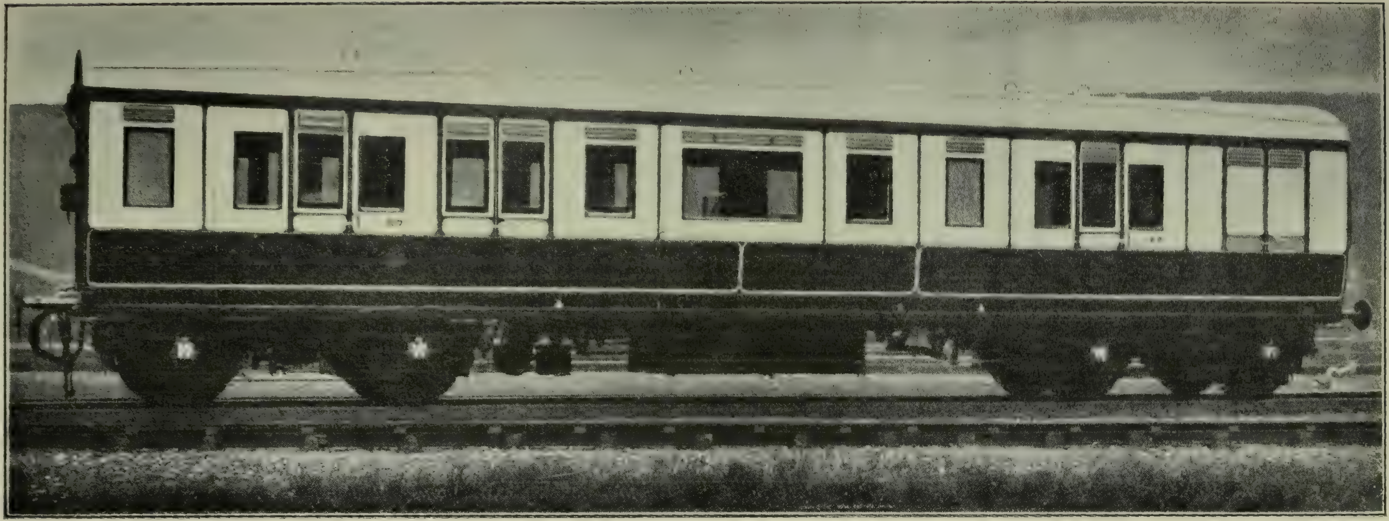


Fig. 22. — Compartment car for the London & North Western.

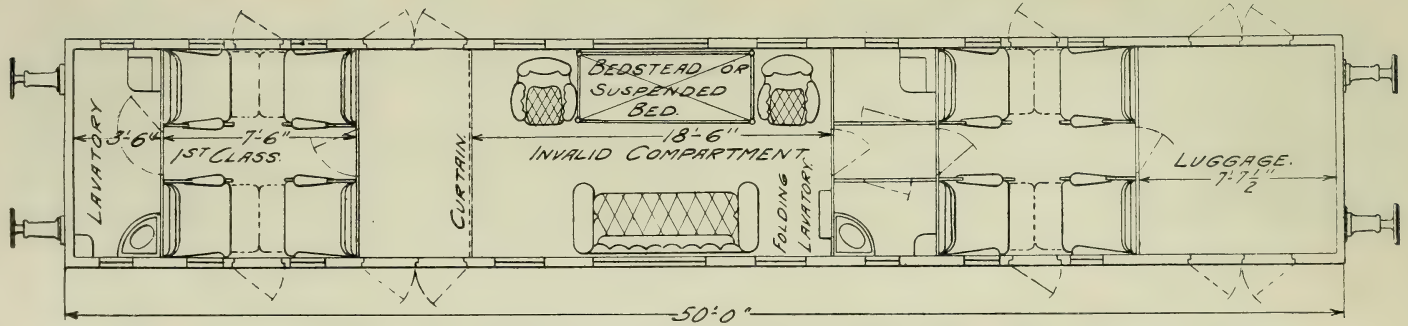


Fig. 23. — Compartment car for the London & North Western. — Plan.

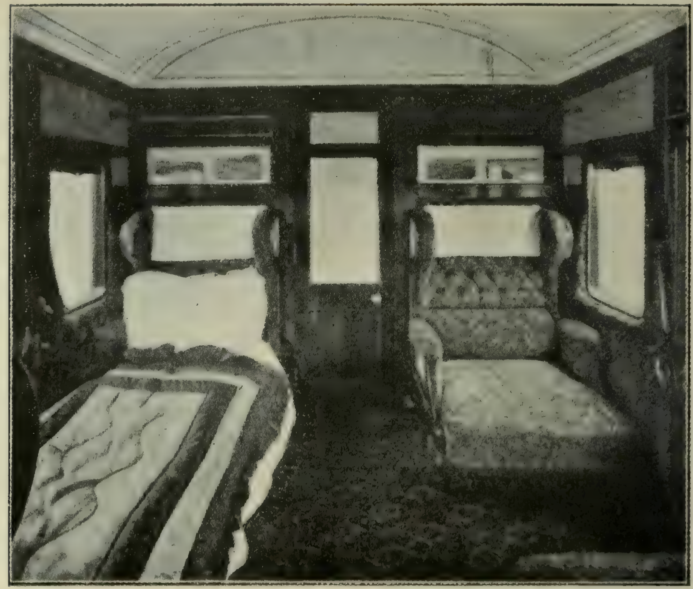


Fig. 24. — Compartment car for the London & North Western. — End compartment.

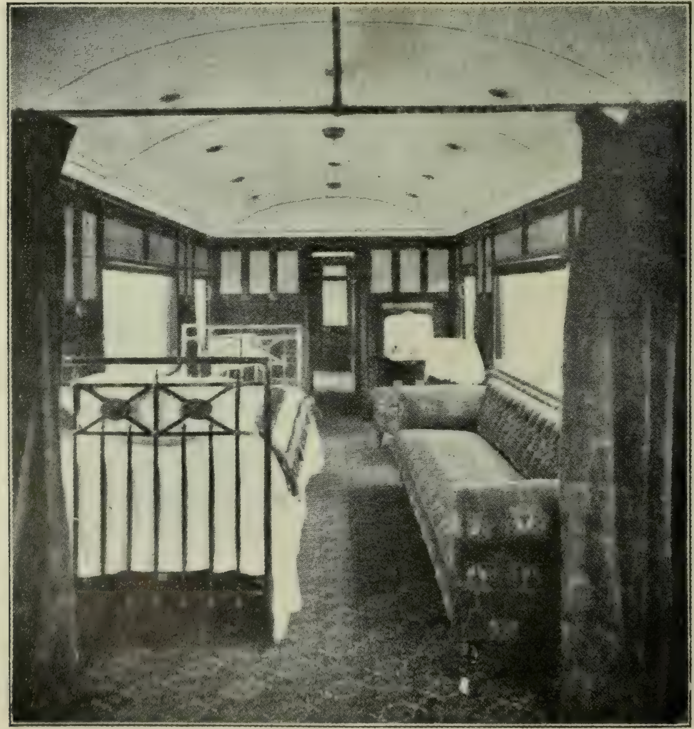


Fig. 25. — Compartment car for the London & North Western. — Invalid compartment.

The ventilation is on the torpedo principle, with torpedoes in the center of the roof, and side ventilation over the doors, etc.

The heating is by the Consolidated steam heating system, the heaters being placed under the chairs, couches, etc., and controlled by valves which can be operated by the passengers. The cars are fitted with the combined automatic vacuum and Westinghouse brakes, and passenger communication between driver and guard.

[625 .236 & 625. 2 (06]

5. — Up-to-date cleaning of passenger equipment.

(Topical discussion at the Master Car Builders' Convention.)

(*Railroad Gazette.*)

Mr. P. H. Peck (Chicago & Western Indiana Railroad). — On the terminal road with which I am connected, from 6,000 to 7,000 cars per month are cleaned. Our coach cleaning yard is elevated and holds about 350 cars. Our force consists of a general foreman, a foreman for each yard (north and south), a night foreman and about 130 men all told. The entire force is paid by the day. The power house is in the north yard and furnishes steam, air and electricity for the entire yard. The pipes and wires are carried in a conduit 5 feet square, so that in case of derangement they are easily accessible. A Bowser oil storage system is installed at the center of the yard, and we have pumps 400 feet each way from the center of each subyard, which avoids carrying oil any great distance.

From what I have observed and been told, I am led to believe that the vacuum system is not as well adapted for the floors and carpets of cars as the compressed air system, but for seats and draperies, the vacuum is probably preferable. In order, therefore, that really up-to-date cleaning of cars can be obtained, a yard should be equipped with both systems, because cars could be cleaned better and in less time.

For the proper cleaning of cars, the carpets should first be removed to permit a thorough cleaning of all corners and under pipes, etc., in the car. While the carpets are removed and being cleaned, the floor of the car should be thoroughly cleaned by compressed air and then scrubbed. The carpets should be replaced and the vacuum system used to clean the seats, draperies, and other parts of the car.

Coach cleaning may be divided into three parts :

1° *Inside cleaning.* — This is for sanitary purposes, and for the health and comfort of the passengers ;

2° *Outside cleaning.* — This is for outside appearances and to preserve the paint and varnish. For this purpose nearly all roads use some kind of a cleaner ; some buy it, others make it themselves. Personally I believe a good cleaner is beneficial to the varnish ;

3° *Trucks and under rigging.* — I visited all the coach terminals in Chicago, and find that thrucks are wiped chiefly by the use of a brush and a bucket of oil. This makes the trucks look very fine before a train leaves the station, and also has a tendency to prevent the springs and bolts from rusting, but after the car has run a few miles in dusty weather, the trucks bear very little evidence of ever having been cleaned.

The road with which I am connected, does the cleaning of passenger equipment in Chicago for the Wabash, Monon, Erie and Grand Trunk roads besides our own equipment. I have some figures showing the average cost of cleaning the different kinds of passenger equipment cars.

	Dollars.
Sleeping car	1·96
Suburban coach	0·32
Coach with oil lamps and closets	0·26 $^{2}/_{3}$
50-foot baggage car	0·22
50-foot combination mail and baggage	0·27
60-foot mail car	0·47
60-foot baggage car	0·32
Wide vestibule coach	1·29
Combination coach and baggage	0·63
Wide vestibule chair car	1·48
Platform coach	0·48
Dining car	1·85
Parlor car	0 76

During the year 1906, we cleaned 89,026 passenger equipment cars at an average cost per car of 77·8 cents.

President Fowler. — Mr. Peck probably has charge of the largest car-cleaning establishment on the continent, so that the information we get from him is extremely valuable.

Mr. Wm. McIntosh (Central Railroad of New Jersey). — The road I am connected with, has a vacuum system installed in the passenger cleaning yards at Jersey City. It has been in operation for about two years and is doing satisfactory work, especially with the upholstering and interior trimming. We are so well satisfied with it that we consider it indispensable to a well-equipped passenger car cleaning yard.

Mr. F. W. Brazier (New York Central Lines). — We do a great deal of what we term " E " cleaning. We give our cars an " E " cleaning once in every three months if they require it. Then we try to keep water off our cars as much as we can; we believe that the dry wiping maintains a better surface on the car, and that the longer you keep water off the better off you are. We use on our limited trains what we call " thinner oil, " very thin, wiped down so as to make you think when you get on the car that you are in a new train.

Mr. B. Julien (Union Pacific Railroad). — On the Union Pacific, prior to two years ago, we used the straight air. Since that time we have been using the vacuum system, something that we fixed up ourselves. The vacuum system is better for the plush; it does nost strain it as much as the straight air does, and we have better results all around. Also, it is a cheaper system of cleaning than the straight air, as there is not so much wiping to do afterward.

Mr. C. A. Schroyer (Chicago & North-Western Railway). — We clean about 400 cars a day in Chicago. We have one yard fitted up in what we consider a modern manner, with steam, air and water. We use straight air for blowing out the dust upon the varnish and in the blinds and curtains, blowing it out of the cushions and backs. I have thought that I should like to have the vacuum system, but we cannot have it in our yard unless we use it in connection with the straight air system, and we think that that costs too much money because straight air is pretty expensive. I have also thought that it would be wise to use the vacuum system in connection with steam, running steam pipes out into the yard and producing the vacuum. Both of those methods are now in use, but I think a better one would be to have a little exhaust fan run by a motor and take that right along from car to car, running a wire down from an electric line for power.

President FOWLER. — The lack of facilities, poor yards, etc., is a point that ought to be brought to the notice of the parties responsible. It is impossible for those in charge of car cleaning to get good work done unless the cars are set where the conveniences are located.

Mr. W. E. SYMONS. — I ask what character of cleaning Mr. Peck's figures referred to. If in the sleeping cars, it covered the sleeping car equipment and also the outside of the coach body, and if so, the quality of cleaning material used on the outside of the car.

Mr. PECK. — The figures I gave were the general average for all cars. Some roads run fine trains and are very particular about dust and thorough cleaning. Other roads run a great many common cars — express cars and so on — and they do no cost so much.

Mr. SYMONS. — Does the average include sleepers?

Mr. PECK. — No. The Pullman Company, at tends to its own cleaning, with the exception of the Grand Trunk, which does all the inside cleaning of Pullmans, and we do the outside.

Mr. SCHROYER. — On the North-Western it is costing about $8·75 to clean a sleeping car.

Mr. R. F. McKENNA (Delaware, Lackawanna & Western Railroad). — Where the terminal is of sufficient size to warrant it, there should be a shed capable of holding a number of cars in proportion to the equipment handled at that point, and at stated periods, whatever may be deemed necessary according to the service, the cars should be taken out of service and given what might be termed a light shopping; that is, giving them a thorough exterior cleaning with an emulsion of some character, and having the interior finish rubbed down with polish. At the same time, it permits of painting the trucks and platforms and gives a tone to the car which keeps it in good condition up to the time of its next shopping.

Mr. J. W. MARDEN (Boston & Maine Railroad). — I should like to know whether the car cleaning is done entirely by day-work or by piece-work; and if piece-work, what success has been attained?

Mr. PECK. — Ours is entirely day-work. There is some piece-work in Chicago, and I find they have less men, but the less number of men draw as much pay as the larger number of men in day-work.

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6. — A tabular comparison of r

Arranged i

FREIGHT LOCOMOTIVES O

TYPE.							C
Name of road	P. B. & L. E.	D. & H.	L. S. & M. S.	L. S. & M. S.	N. Y. C.	P. R. R.	W
Road number or class	150	1,011	5,962	G-46	G-4	2,762	
Builder	Pittsburg.	American.	American.	American.	American.	Americ.	
When built	1900	1906	1906	1903	1903	1905	
Simple or compound	Simple.	Simple.	Simple.	Simple.	Tan. comp.	Simple.	S
Tractive effort, in lb.	63,800	49,690	45.677	46,500	46,600	45,700	
Weight, total, in lb.	250,300	246,500	232.500	230,000	225,000	220,000	2
Weight on drivers, in lb.	225,200	217,500	207.000	203,000	200,000	198,000	1
Weight on trucks, in lb.	25,100	29,000	25,500	27,000	25,000	22,000	
Weight, tender loaded, in lb.	141,000	152,400	149,600	148,000	137,500	140,500	
Wheel base, driving	15′ 7″	17′ 0″	17′ 6″	17′ 3″	15′ 0″	17′ 6″	15
Wheel base, engine	24′ 4″	25′ 11″	26′ 5″	26′ 5″	23′ 7″	26′ 5″	24
Wheel base, engine and tender	57′ 11 3/4″	57′ 7 1/2″	60′ 9 1/2″	57′ 9 3/4″	59′ 1″	60′ 3 3/4″	57
Diameter of drivers	54″	57″	63″	58″	51″	63 ″	
Cylinders, number	2	2	2	2	4	2	
Cylinders, diameter and stroke	24″ × 32″	23″ × 30″	23″ × 32″	23″ × 30″	16″ and 30″ × 30″	23″ × 32″	22′
Valve gear, type	Steph.	Wals.	Wals.	Steph.	Steph.	Steph.	
Steam pressure, in lb.	220	210	200	200	200	200	
Boiler, type	Str.	Wooten.	Rad. stay.	W. T.	E. W. T.	Str.	
Boiler, smallest diameter	84″	83 3/4″	81 5/8″	80″	77″	80″	
Boiler, height center	119 3/4″	113″	118 1/4″	119 1/2″	111″	117″	
Heating surface, tubes, in square feet	3,564	3,716	3,492·18	3,725	3,915	3,600	
Heating surface, firebox, in square feet	241	329·5	213·05	232	227	182	
Heating surface, total, in square feet	3,805	4,045·5	3,705·23	3,957	4,142	3,782	
Heating surface, superheater, in square feet	...	...	...	...	...	...	
Grate area, in square feet	36·8	99·85	56·5	55	58	55·4	
Firebox, length	132″	126 1/8″	108 1/8″	108″	105 1/8″	106″	1
Firebox, width	40 1/4″	114	75 1/4″	73 1/4″	75 3/8″	75 1/4″	
Fuel, kind	Bit. coal.	Anth. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bi
Tubes, number firetube	406	493	446	461	507	446	
Tubes, number superheater	...	...	...	...	...	...	
Tubes, diameter, firetube	2 1/4″	2″	2″	2″	2″	2″	
Tubes, diameter, superheater	...	...	...	...	...	...	
Tubes, length	15′	14′ 6″	15′	15′ 6 1/8″	14′ 9″	15′ 4 3/4″	1
Tender, coal capacity, in tons	14	14	12	16	12	13 1/2	
Tender, water capacity, in gallons	7,500	7,800	7,500	7,500	7,000	7,000	
Weight on drivers ÷ tractive effort	3·58	4·37	4·5	4·37	4·3	4·3	
Weight total ÷ tractive effort	3·95	4·97	5·0	4·95	4·85	4·8	
T. E. × diameter drivers ÷ total H. S.	900·0	700·0	775·0	680·0	575·0	760·0	
Total heating surface ÷ grate area	103·0	40·5	65·8	72·0	71·0	68·0	
Firebox heating surface ÷ total H. S. %	6·34	8·12	5·75	5·85	5·5	4·82	
Weight on drivers ÷ total heating surface	59·0	53·5	55·8	51.2	48·5	52·0	
Weight total ÷ total heating surface	65·8	60·8	62·5	58·0	54·5	58·0	
Equated heating surface (2)	1,161·0	1,304·5	1,116·05	1,179·0	1,252·0	1,102·0	
Equated heating surface ÷ grate area	31·7	13·1	19·8	21·4	21·5	20·0	
Tractive effort × diameter drivers ÷ equated H. S.	2,960·0	2,160·0	2,580·0	2,300·0	1,900·0	2,600·0	2,
Total H. S. ÷ superheating surface	...	...	...	...	...	...	
Cylinder volume, in cubic feet	16·75	14·4	15·4	14·4	13·3 (1)	15·4	
Total heating surface ÷ cylinder volume	258·0	280·0	242·0	275·0	310·0	246·0	
Equated heating surface ÷ cylinder volume	69·5	90·5	72·2	82·0	94·0	71·8	
Superheating heating surface ÷ cylinder volume	...	...	...	...	...	...	
Grate area ÷ cylinder volume	2·19	6·92	3·66	3·8	4·35	3·6	
Reference in *The American Engineer*	1900 p. 214.	1907 p. 22.	1906 p. 263.	1903, p. 415, 1904, p. 11.	1903 p. 174.	1906 p. 73.	

(1) = Equivalent simple cylinders. (2) = Tube heating surface $\div \sqrt{\text{length tubes}}$ + firebox heating surface.

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(1) From the *American Engineer and Railroad Journal.*

ples of recent locomotives (1).

al weights.

OLIDATION OR 2-8-0 TYPE.

N.

N. P.	B. & O.	Har. lines.	C. S. N. O. & P.	P. R. R.	C. B. & Q.	M. St. P. & Ŝ. S. M.	W. P.	C. R. I. & P.	C. P. R.	C. of G.
...	2,503	C-187	...	H 6 B	D4	445	...	55D	M4	1,200
merican.	Americ.	Bald.	Bald.	Bald.	American.	American.	Bald.	Bald.	Shops.	Bald.
1901	1905	1905	1907	1905	1903	1905	1906	1906	1901-1906	1907
n. comp.	Simple.	Simple.	Simple.	Simple.	Simple.	Comp.	Simple.	Simple.	Simple.	Simple.
44,900	41,100	43,299	43,300	42,200	42,500	37,300	44,100	39,600	36,800	34,000
209,500	208,500	208,000	207,000	204,470	202,600	201,500	201,330	198,600	186,200	163,390
185,500	185,900	187,000	182,000	181,170	179,200	174,000	186,330	177,300	163,700	143,290
24,000	22,600	21,000	27,000	23,300	23,400	27,500	15,000	21,300	22,525	20,100
...	143,500	135,050	148,000	143,000	150,200	116,900	...	140,300	121,400	119,610
5' 0"	16' 8"	15' 8"	16' 0"	16' 3"	15' 8"	17' 0"	15' 8"	17' 0"	15' 10"	16' 0"
3' 8"	25' 7"	24' 4"	24' 4"	24' 9"	24' 6"	25' 11"	24' 4"	26' 0"	24' 4 1/2"	24' 3 1/2"
2' 4 1/2"	59' 8 1/4"	55' 11 3/4"	56' 3"	58' 1 1/2"	69' 1 1/4"	55' 8 1/4"	57' 11 1/2"	58' 0"	53' 4 1/4"	53' 9"
55"	60"	57"	57"	56"	57"	63"	57"	63"	57"	56"
4	2	2	2	2	2	2	2	2	2	2
d 28" × 34"	22" × 30"	22" × 30"	22" × 30"	22' × 28"	22" × 28"	23" and 35" × 34"	22" × 30"	23" × 30"	21" × 28"	20" × 28"
Steph.	Steph.	Steph.	Wals.	Wals.	Steph.	Steph.	Steph.	Wals.	Steph.	Steph.
200	205	200	200	205	210	210	200	185	200	200
. W. T.	Str.	Str.	Str.	Belp.	Str.	E. W. T.	Str.	E. W. T.	E. W. T.	W. T.
75"	74' 5"	80"	78"	71"	79 1/2"	67 3/8"	80"	74"	69"	61"
11 1/4"	118"	114"	115 1/2"	108 1/4"	115"	115"	...	117"	111 1/2"	105 3/8"
,450·4	2,630·1	3,226	2,939	2,675·9	3,511·56	2,407·5	2,927	2,427	2,216	2,069·3
195·9	179·3	177	183	166 5	221·77	158·0	214	168	165	140·0
,646·3	2,809·4	3,403	3,122	2,842·4	3,733·33	2,565·5	3,141	2,595	2,381	2,209·3
...	...	...	...	...	...	261·4	...	...	375	...
52·3	56·24	49·5	51	49·11	54·2	46·8	33·6	50	43	44
0"	107 5/8"	108"	108"	107"	108 3/8"	96 1/8"	121"	107"	96 5/8"	96 1/8"
75 1/4"	75 1/4"	66"	68"	66"	72"	70 1/4"	40"	67 1/4"	65 1/4"	66"
t. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.
442	282	413	386	373	450	224	390	340	244	283
...	...	...	...	...	...	40	...	...	22	...
2"	2 1/4"	2"	2"	2"	2"	2"	2"	2"	2"	2"
...	...	...	...	...	...	3 1/2"	...	...	5"	...
15'	15' 10"	15'	14' 6 1/2"	13' 8 1/2"	15'	15' 9"	14' 5"	15' 6"	14' 1 3/8"	14' 8"
10	15	14	12	13 1/2	14	10	14	12	10	8
5,500	7,000	7,000	7,500	7,000	8,000	6,000	8,000	7,000	5,000	6,000
4·1	4·5	4·3	4·2	4·3	4·2	4·65	4·2	4·5	4·4	4·2
4·67	5·1	4·8	4·76	4·8	4·8	5·4	4·55	5·0	5·1	4·8
680·0	875·0	725·0	790·0	830·0	650·0	830·0	800·0	965·0	800·0	860·0
69·0	50·0	69·0	61·0	58·0	69·0	55·0	93·0	52·0	55·0	50·0
5·4	6·35	5·2	5 85	5·9	5·9	6·15	6·8	6·5	6·9	6·3
51·0	66·0	55·0	58·2	63·5	48·0	48·7	59·5	68·0	69·5	65·0
59·0	74·0	61·0	66·0	72·0	54·0	56·5	64·0	77·0	78·0	74·0
,085·9	839·3	1,012·0	953·0	891·5	1,129·77	764·0	984·0	785·0	755·0	680·0
20·7	14·8	20·5	18·8	18·2	20·5	16·3	29·4	15·7	17·5	15·5
270·0	2,910·0	2,440·0	2,590·0	2,650·0	2,150·0	3,070·0	2,550·0	3,180·0	2,780 0	2,800·0
...	...	...	...	...	...	9·85	...	...	6·35	...
14·2 (1)	13·2	13·2	13·2	12·4	12·4	11·4 (1)	13 2	14·4	11·2	10·2
256·0	213·0	259·0	236·5	229·0	302·0	312·0	238·0	180·0	213·0	217·0
76·5	63·3	76·5	72·0	72·0	91·0	67·0	74·5	54·3	67·0	66·5
...	...	...	...	...	...	23·0	...	...	33·3	...
3·8	4·3	3·75	3·87	3 95	4·4	4·1	2·55	3·48	3·8	4·3
...	1906	1905	1907	1906	1903	1905	...	1907	1906	1907
...	p. 31.	p. 154.	p. 194.	p. 231.	p. 48.	p. 150.	...	p. 147.	p. 165.	p. 31,

A tabular comparison of not

Arranged with re

FREIGHT LOCOMOTIVES OF OT

TYPE.	MALLET.				SANTA FE (2-10-2).	
Name of road	Erie (1).	G. N.	B. & O.	G. N. (1)	P. S. & N. (1)	A. T. & S.
Road number or class	...	L-1	2,400	...	98	900
Builder	American.	Bald.	American.	Bald.	Bald.	Bald.
When built	1907	1906	1904	1907	1907	1903
Simple or compound	Comp.	Comp.	Comp.	Comp.	Simple.	Tan. com
Tractive effort, in lb.	98,000	71,600	70,000	57,760	60,000	62,800
Weight, total, in lb.	410,000	355,000	334,500	288,000	288,000	287,240
Weight on drivers, in lb.	410,000	316,000	334,500	250,000	235,000	234,580
Weight on trucks, in lb.	...	19,000	...	18,000	...	23,420
Weight on trailer, in lb.	...	20,000	...	20,000	...	29,240
Weight, tender loaded, in lb.	163,000	148,000	143,000	152,000	162,000	158,500
Wheel base, driving	14' 3''	10' 0''	...	9' 10''	19' 9''	19' 9''
Wheel base, engine	39' 2''	44' 10''	30' 8''	43' 7''	35' 11''	35' 11''
Wheel base, engine and tender	72' 2''	73' 2 1/4''	61' 7''	72' 0 1/4''	67' 4 1/2''	66' 0''
Diameter of drivers	51''	55''	56''	55''	57''	57''
Cylinders, number	4	4	4	4	2	4
Cylinders, diameter	25'' and 39''	21 1/2 and 33''	20'' and 32''	20'' and 31''	28''	19'' and 32
Cylinders, stroke	28''	32''	32''	30''	32''	32''
Valve gear, type	Wals.	Wals.	Wals.	Wals.	Wals	Steph.
Steam pressure, in lb.	215	200	235	210	160	225
Boiler, type	Conical.	Belp.	Str.	Belp.	E. W. T.	W. T.
Boiler, smallest diameter	84''	84''	84''	72''	78 3/4''	78 3/4''
Boiler, height center	...	120''	120'	116''	118''	118''
Heating surface, tubes, in square feet	5,760	5,473	5,380	3,708	4,586	4,587
Heating surface, firebox, in square feet	348	230	220	198	210	209
Heating surface, total, in square feet	6,108	5,703	5,600	3,906	4,796	4,796
Heating surface, superheater, in square feet	...	...	...	...	762	...
Grate area, in square feet	100	78	72·2	53·4	58·5	58·5
Firebox, length	126''	117''	108 1/8''	116 1/8''	108''	108''
Firebox, width	114''	96''	96 1/4''	66 1/4''	78''	78''
Fuel, kind	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal
Tubes, number firetube	468	441	436	301	391	391
Tubes, number superheater	...	...	...	...	...	...
Tubes, diameter, firetube	2 1/4''	2 1/4''	2 1/4''	2 1/4''	2 1/4''	2 1/4''
Tubes, diameter, superheater	...	...	...	...	...	...
Tubes, length	21' 0''	21' 0''	20' 10 3/4''	21' 0''	20' 0''	20' 0''
Tender, coal, capacity, in tons	16	13	16	13	14	14
Tender, water capacity, in gallons	8,500	8,000	7,000	8,000	8,500	8,500
Weight on drivers ÷ tractive effort	4·18	4·4	4·75	4·34	3·91	3·75
Weight total ÷ tractive effort	4·18	4·95	4·75	5·0	4·8	4·56
T. E. × diameter drivers ÷ total H. S.	820·0	690·0	700·0	813·0	712·0	747·0
Total heating surface ÷ grate area	61·0	73·0	77·3	73·0	81·8	81·8
Firebox heating surface ÷ total H. S. %.	5·7	4·13	3·92	5·05	4·38	4·34
Weight on drivers ÷ total heating surface	61·0	55·2	59·5	63·9	49·0	48·8
Weight total ÷ total heating surface	61·0	62·0	59·5	73·8	60·0	59·8
Equated heating surface	1,598·0	1,425·0	1,400·0	1,008·0	1,240·0	1,239·0
Equated heating surface ÷ grate area	15·98	18·3	19·4	18·9	21·25	21·2
Tractive effort × diameter drivers ÷ equated H. S.	3,130·0	2,770·0	2,800·0	3,170·0	2,760·0	2,880·0
Total H. S. ÷ superheating heating surface	...	...	...	...	6·3	...
Cylinder volume, in cubic feet	24·0	20·75	19 0	17·1	22·82	17·9
Total heating surface ÷ cylinder volume	255·0	275·0	295·0	229·0	210·0	268·0
Equated heating surface ÷ cylinder volume	66·8	68·8	73·5	59·0	54·1	69·0
Superheating heating surface ÷ cylinder volume	...	...	...	...	33·4	...
Grate area ÷ cylinder volume	4·17	3·75	3·85	3·14	2·57	3·28
Reference in *The American Engineer*	1906 p. 429.	1906 p. 371.	1904 p. 237, 262.	This issue.	1907 p. 88.	1903, p. 372, 3 1904, p. 17

(1) Builders' weights. (2) Combustion chamber 3' long.

es of recent locomotives.

es and weights.

THAN THE CONSOLIDATION.

CAPOD (2-10-0).		MIKADO (2-8-2).		TEN WHEEL (4-6-0).		MOGUL (2·6-0).	(0-10-0).	(0-8-0).	(0-6-0).		
P. 1	A. T. & S. F.	N. P.	N. P.	C. & E. I.	C. P. R.	Vandalia.	L. S. & M. S.	C. & O.	P. & L. E.	P. R. R.	B. & O.
	987	W.	1,608	289	D-10	V-F. 5 a	M.	8	253	B-6	D-23
an.	Bald.	American.	Americ.	Bald.	C. P. R.	Americ.	American.	Americ.	American.	P. R. R.	American.
7	1902	1905	1906	1905	1905-1906	1907	1905	1903	1906	1904	1906
le.	Tan. comp.	Tan. comp.	Simple.	Bal. comp.	Simple.	Simple.	Simple.	Simple.	Simple.	Simple.	Simple.
50	62,500	45,000	46,630	31,000	33,300	31,360	55,300	41,000	44,100	36,100	29,740
00	266,500	271,000	261,000	191,060	190,000	187,000	270,000	171,175	178,200	170,000	161,080
00	237,000	207,000	205,000	145,260	141,000	159,300	270,000	171,175	178,200	170,000	161,080
	29,500	30,300	26,000	45,800	49,000	27,700	...	...	...	...	...
	...	33,700	30,000	...	...	...	...	...	...	...	...
00	132,000	148,500	177,800	120,000	123,700	144,800	...	121,160	121,300	132,500	85,000
	20' 4"	16' 6"	16' 6"	13' 6"	14' 10"	14' 9"	19' 0"	13' 7 1/2"	12' 0"	11' 6"	11' 0"
	29' 10"	34' 9"	34' 9"	27' 7"	26' 1"	23' 10"	19' 0"	13' 7 1/2"	12' 0"	11' 6"	11' 0"
/2"	59' 6"	63' 1"	63' 1"	55' 8"	54' 6 3/4"	56' 10 1/4"	54' 5 1/2"	45' 8"	46' 2 1/4"	48' 3 1/4"	40' 9 1/2"
	57"	63"	63"	62"	63"	63"	52"	51"	50"	56"	52"
	4	4	2	4	2	2	2	2	2	2	2
	19" and 32"	19" and 30"	24"	15 1/2" and 26"	21"	21"	24"	21"	21"	22"	19"
	32"	30"	30"	26"	28"	28"	28"	28"	30"	24"	28"
ls.	Steph.	Steph.	Wals.	Steph.	Steph.	Wals.	Wals.	Steph.	Steph.	Steph.	Steph.
	210	200	200	225	200	200	210	200	200	205	180
al.	W. T.	E. W. T.	E. W. T.	W. T.	E. W. T.	Str.	W. T.	W. T.	Str.	Belp.	Wooten.
	78 3/4"	75 3/4"	75 3/4"	64"	70 3/8"	76 5/8"	80 1/16"	67"	80"	67 1/4"	70"
	118"	118"	118"	109"	113 1/2"	115 1/2"	115"	112 1/2"	108 1/2"	108"	105"
·0	5,155·8	3,819	3,192	2,933·7	2,233	2,754·6	4,422·6	2,573	2,906·0	2,343·0	1,476 67
·5	234·2	200	245 (2)	160·7	180	180·4	197·0	164	206·0	152·1	172·84
·5	5,390·0	4,028	3,437	3,094·4	2,413	2,935·0	4,619·6	2,737	3,112·0	2,495·1	1,649·5
	...	...	...	...	378	...	...	...	...	...	...
	58·5	43·5	43·5	46·69	49·5	52	55·4	38·8	33·3	41·25	73·33
	108"	96"	96"	101 7/8"	102 1/8"	108 1/8"	108 1/8"	80"	120"	90"	110"
	78"	65 1/4"	65 1/4"	66"	69 7/8"	69 1/4"	73 1/4"	70"	40"	66"	96"
al.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	An. coal.
	463	374	372	278	266	390	447	351	430	325	220
	...	...	...	...	22	...	...	...	...	...	...
	2 1/4"	2"	2"	2 1/4"	2"	2"	2"	2"	2"	2"	2 1/4"
	...	...	...	...	5"	...	...	...	...	...	...
"	19' 0"	19' 6"	16' 6"	18' 0"	14' 2 7/8"	13' 5 7/8"	19' 0"	14' 0"	13' 0"	13' 10 1/4"	11' 6"
	11	12	12	12	10	13	12	7	10	11	6
	7,000	8,000	10,000	6,000	5,000	7,500	8,000	6,000	7,000	5,500	4,000
47	3·82	4·6	4·38	4·67	4·24	5·05	4·86	4·15	4·04	4·7	5·4
12	4·26	6·0	5·6	6·15	5·7	5·9	4·86	4·15	4·04	4·7	5·4
0	661·0	705·0	855·0	620·0	870·0	675·0	625·0	763·0	710 0	810·0	940·0
3	92·0	92·5	78·8	66·0	48·6	56·4	83·0	70·5	94·0	60·3	22·5
2	4·33	5·18	7·12	5·18	7·42	6·14	4·25	5·93	6·6	6·08	10·5
1	43·8	51·1	59·6	46·7	58·5	54·1	58·3	62·3	57·1	68·0	97·3
3	49·3	65·9	75·5	61·6	78·5	65·5	58·3	62·3	57·1	68·0	97·3
5	1,419·2	1,073·0	1,030·0	850·7	770·0	930·4	1,212·0	851·0	1,011·0	782·1	607·84
6	24·3	24·7	23·7	18·2	15·5	18·0	21·8	21·9	30·4	19·0	8·25
0	2,520·0	2,650·0	2,850·0	2,260·0	2,730·0	2,120·0	2,380·0	2,450·0	2,180·0	2,570·0	2,550·0
	...	...	...	...	6·30	...	...	...	...	...	...
6	19·4	15·8	15·8	8·93	11·2	11·2	14·7	11·2	12·0	10·5	9·2
0	278·0	255·0	218·0	346·0	215·0	263·0	314·0	245·0	260·0	238·0	179·0
5	74·1	68·0	65·2	95·5	68·7	83·0	82·5	76·2	84·0	74·3	65·5
	...	...	...	...	33·8	...	...	...	...	...	...
81	3·0	2·75	2·76	5·2	4·43	4·65	3·78	3·48	2·77	3·95	7·95
	1902	1905	1906	1905	1906	1907	1905	1904	1906	1904	1906
3.	p. 192.	p. 367.	p. 392	p. 97.	p. 165.	p. 27.	p. 330.	p. 184.	p. 346.	p. 384.	p. 257.

A tabular comparison of r

Arranged with

PASSENGER LOCOMOTIVES O

TYPE.						
Name of road	N. P.	O. R. & N.	Erie.	B. & O.	C. B. & Q.	Mex
Road number or class	2,175	194	2,511	P	Sl.	4
Builder	American.	Baldwin.	American.	American.	...	Bal
When built	1906	1905	1905	1906	1906	1
Simple or compound	Compound.	Compound.	Simple.	Simple.	Simple.	Com
Tractive effort, in lb.	30,340	28,300	30,300	35,020	31,100	35
Weight, total, in lb.	240,000	231,300	230,500	229,500	228,000	227
Weight on drivers, in lb.	157,000	143,600	149,000	150,500	150,000	147
Weight on trucks, in lb.	53,000	43,400	41,000	40,500	42,000	.
Weight on trailer, in lb.	30,000	44,300	40,500	38,500	36,000	.
Weight, tender loaded, in lb.	141,350	159,000	163,000	147,000	148,200	142
Wheel base, driving	12′ 0″	13′ 4″	13′ 0″	13′ 2″	12′ 10″	12′
Wheel base, engine.	33′ 5″	33′ 7″	33′ 8″	34′ 3 1/2″	32′ 9″	33′
Wheel base, engine and tender.	62′ 10″	64′ 1 1/2″	65′ 1″	66′ 3 3/4″	64′ 3 1/4″	62′
Diameter of drivers	69″	77″	74″	74″	74″	6
Cylinders, number	4	4	2	2	2	
Cylinders, diameter	16 1/2″ and 27 1/2″	17″ and 28″	22 1/2″	22″	22″	17″ a
Cylinders, stroke	26″	28″	26″	28″	28″	2
Valve gear, type	Wals.	Steph.	Steph.	Steph.	Steph.	St
Steam pressure, in lb.	220	200	200	225	200	2
Boiler, type	E. W. T.	Str.	Str.	Str.	W. T.	W
Boiler, smallest diameter	72 1/4″	70″	74 5/8″	72″	70″	7
Boiler, height center	115″	...	113 1/2″	112″	109 3/4″	1
Heating surface, tubes, in square feet	2,667·0	2,874·0	3,131·0	3,234·6	3,732·0	3,5
Heating surface, firebox, in square feet	241·8	179·0	195·0	179·4	200·0	1
Heating surface, total, in square feet.	2,908·8	3,053·0	3,326·0	3,414·0	3,932·0	3,7
Heating surface, superheater, in square feet	...	...	763·0	...	...	
Grate area, in square feet.	43·5	49·5	56·5	56·24	54·0	
Firebox, length	96″	108″	108 1/8″	108 1/8″	108 1/8″	11
Firebox, width	65 1/4″	66″	75 1/4″	75 1/4″	72 1/4″	6
Fuel, kind	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit.
Tubes, number firetube	306	245	195	276	303	3
Tubes, number superheater	...	...	32	...	...	
Tubes, diameter, firetube	2″	2 1/4″	2 1/4″	2 1/4″	2 1/4″	2
Tubes, diameter superheater.	...	...	5″	...	...	
Tubes, length	16′ 9″	20′ 0″	20′ 0″	20′ 0″	21′ 0″	20
Tender, coal capacity, in tons	12	10	16	15	13	
Tender, water capacity, in gallons.	7,000	9,000	8,500	7,000	8,000	7,
Weight on drivers ÷ tractive effort	5·2	5·05	4·95	4·3	4·8	
Weight, total ÷ tractive effort	7·9	8·2	7·7	6·6	7·3	
T. E. × diameter drivers ÷ total H. S.	720·0	713·0	669·0	760·0	585·0	6
Total heating surface ÷ grate area	67·0	61·7	58·7	60·5	71·3	
Firebox heating surface ÷ total H. S. %	8·3	5·85	5·85	5·23	4·85	
Weight on drivers ÷ total heating surface	53·8	47·0	45·0	44·0	38·0	
Weight total ÷ total heating surface	82·5	75·0	69·5	66·5	58·0	
Equated heating surface	893·8	820·0	895·0	901·4	1,013·0	8
Equated heating surface ÷ grate area	20·5	16·6	15·8	16·1	18·7	
Tractive effort × diameter drivers ÷ equat. H. S.	2,340.0	2,660·0	2,480·0	2,880·0	2,280·0	2,6
Total H. S. ÷ superheating heating surface.	...	...	4·35	...	...	
Cylinder volume, cubic feet	9·9 (1)	11·6 (1)	12·0	12·3	12·3	
Total heating surface ÷ cylinder volume	294·0	265·0	277·0	278·0	318·0	3
Equated heating surface ÷ cylinder volume	90·5	70·5	74·5	73·0	82·0	
Superheated heating surface ÷ cylinder volume.	...	...	63·5	...	...	
Grate area ÷ cylinder volume	4·3	4·28	4·7	4·56	4·39	
Reference in *The American Engineer*	1906, p. 411.	1905, p. 246.	1905, p. 172.	1906, p. 257.	1906, p. 300.	1907,

(1) Equivalent simple cylinders.

les of recent locomotives.

es and weights.

IC (4-6-2) AND PRAIRIE (2-6-2) TYPES.

							PRAIRIE.				
: S. F.	Har. lines.	C. & A.	M. C.	So. Ry.	C. P. R.	C. R. I. & P.	A. T. & S. F.	L. S. & M. S.	C. B. & Q.	N. P.	G. N.
51	P.141.	602	K-80	1,238	Gla.	841	1800	4,724	R5	2,378	J1.
win.	Baldwin.	Baldwin.	American	Baldwin.	C. P. R.	American.	Baldwin.	American.	American.	Americ.	Baldwin.
5	1905	1904	1904	1906	1906	1905	1906	1906	1906	1906	1906
und.	Simple.	Simple.	Simple.	Simple.	Simple.	Simple.	Compound.	Simple.	Simple.	Simple.	Simple.
300	29,920	29,900	28,500	34,940	28,000	31,000	37,800	27,850	35,060	33,300	37,560
700	222,000	221,500	221,000	219,500	212,000	212,000	248,200	233,000	216,000	209,500	209,000
00	141,000	135,110	140,500	138,460	139,000	143,500	174,700	165,200	152,000	152,000	151,000
00	37,000	40,500	42,500	39,740	39,000	34,500	31,300	26,000	25,600	...	21,000
00	44,000	45,490	38,000	41,300	34,000	34,000	42,200	41,800	38,400	...	37,000
	162,200	166,600	122,600	136,800	122,700	150,000	175,000	159,900	148,200	139,500	151,000
'	13' 4"	13' 4"	13' 0"	12' 6"	13' 0"	12' 4"	13' 8"	14' 0"	13' 4 1/2"	11' 0"	13' 0"
'	33' 4"	33' 4"	33' 7 1/2"	31' 4 1/2"	33' 7"	32' 0"	33' 9"	34' 3"	30' 8 1/2"	28' 11"	30' 9"
1/2"	63' 10 1/2"	62' 5 1/2"	60' 5"	64' 5 7/8"	59' 3 1/4"	61' 1"	65' 0"	62' 5 1/2"	62' 2 3/4"	57' 3 1/2"	63' 8"
'	77"	77"	75"	72 1/2"	75"	69"	69"	79"	69"	63"	69"
	2	2	2	2	2	2	4	2	2	2	2
1 28"	22"	22"	22"	22"	21"	22"	17 1/2" and 29"	21 1/2"	22"	21"	22"
'	28"	28"	26"	28"	28"	26"	28"	28"	28"	28"	30"
h.	Steph.	Steph.	Steph.	Steph.	Steph.	Steph.	Wals.	Wals.	Steph.	Steph.	Wals.
)	200	20	200	220	200	200	225	200	210	200	210
T.	Str.	Str.	Str.	Str.	E. W. T.	E. W. T.	E. W. T.	E. W. T.	W. T.	E. W. T.	Belp.
'	70"	70"	72 1/4"	70"	66"	68 3/8"	76"	70"	70"	72 1/8"	72"
	113"	113"	113"	109"	112"	113 1/2"	115"	114"	107 3/8"	115"	108"
2·2	2,874·0	2,874·0	3,690·6	3,683·5	2,777·0	3,174·5	3,803·0	3,678·0	3,375·0	2,105·0	3,277·0
2·8	174·0	179·0	207·1	195·0	180·0	179·41	217·0	227·0	200·0	235·0	210·0
5·0	3,048·0	3,053·0	3,897·7	3,878·5	2,957·0	3,353·91	4,020·0	3,905·0	3,575·0	2,340·0	3,487·0
	...	...	...	...	528 0	...	...	...	...	...	...
3·0	49·5	49·5	50·23	54·25	45·6	44·8	53·8	55·0	54·0	43·5	53·15
"	108"	108·0	96 1/8"	108 1/8"	94 1/8"	96 1/16"	107 1/16"	108 1/8"	108 1/8"	96"	116"
4"	66"	66·0	75 1/4"	72 1/4"	69 7/8"	67 1/4"	71 1/4"	73 1/4"	72 1/4"	65 1/4"	66"
.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.
	245	245·0	354	314	193	328	342	322	303	306	301
	...	...	...	...	22	...	...	...	...	...	...
"	2 1/4"	2 1/4"	2"	2 1/4"	2 1/4"	2"	2 1/4"	2 1/4"	2 1/4"	2"	2 1/4"
	...	...	...	...	5"	...	...	...	...	...	...
0"	20' 0"	20' 0"	20' 0"	20' 0"	19' 6"	18' 7"	18' 10 5/16"	19' 6"	19' 0"	13' 3"	18' 6"
0	12	15	10	12 1/2	10	13	14	15	13	12	13
0	9,000	8,400	6,000	7,500	5,000	7,500	9,000	8,000	8,000	7,000	8,000
·6	4·7	4·5	4·9	4·0	4·95	4·6	4·6	4·4	4·3	4·6	4·0
·9	7·4	7·4	7·8	6·3	7·6	6·8	6·6	8·3	6·2	6·3	5·6
·0	755·0	750·0	555·0	653·0	685·0	640·0	650·0	565·0	677·0	900·0	746·0
·0	61.5	61·5	77·0	71·5	65·0	75·0	74·0	71·0	64·8	53·8	65·0
·35	5·70	5·85	5·3	5·0	6·1	5·3	5·4	5·8	5·34	10·1	6·0
·0	46·5	44·0	36 0	35·7	47·0	42·5	43·5	42·0	42·5	65·0	43·5
·0	73·0	72·0	57·0	56·5	71·5	63·0	62·0	61·0	60·7	89.5	60·0
·8	816·0	821·0	1,032·1	1,018·0	807·0	916·4	1,097·0	1,059·0	974·0	813·0	972·0
·0	16·5	16·6	20·5	18·7	17·7	20·5	20·5	19·2	18·1	18·7	18·3
·0	2,830·0	2,800·0	2,075·0	2,500·0	2,610·0	2,330·0	2,400·0	2,080·0	2,480·0	2,580·0	2,680·0
	...	...	...	...	5·6	...	...	...	...	...	...
·6 (1)	12·3	12·3	11·4	12·3	11·2	11·4	12·1 (1)	11·7	12·3	11·2	13·2
·0	248·0	249·0	342·0	316·0	265·0	295·0	334 0	335·0	290·0	209·0	265·0
·5	66·2	66·8	90·5	82·5	72·0	80·2	89·5	90·0	79·0	72·6	73·5
	...	...	...	...	48·0	...	...	...	...	...	...
·55	4·0	4·0	4·39	4·41	4·06	3·93	4·43	4·68	4·46	3·89	4·03
454.	1905, p. 151.	1904,p.133.	1904,p.347.	1906,p. 145	1906,p. 165	1905, p. 282.	1906, p. 435.	1906, p. 204.	1906, p. 300.	1906.p.392	1906, p.365.

A tabular comparison of

Arranged with

PASSENGER LOCOMOTIVES OF

TYPE.						A′
Name of road	U. P.	Erie.	N. Y. C.	P. R. R.	N. Y. C.	C.
Road number or class	21	537	I	2,760	II	
Builder	Baldwin.	American.	Baldwin.	American.	American.	Ba
When built	1906	1905	1905	1905	1904	
Simple or compound	Compound.	Compound.	Compound.	Compound.	Compound.	Co
Tractive effort, in lb.	24,281	23,860	24,200	23,300	24,000	
Weight, total, in lb.	209,000	206,000	204,500	200,500	200,000	1
Weight on drivers, in lb.	110,000	115,000	110,000	117,200	110,000	1
Weight on trucks, in lb.	53,000	52,000	52,400	52,500	50,000	
Weight on trailer, in lb.	46,000	39,000	42,100	30,000	40,000	
Weight, tender loaded, in lb.	162,200	162,800	124,000	132,500	124,000	1
Wheel base, driving	7′ 0″	7′ 0″	7′ 0″	7′ 5″	7′ 0″	7
Wheel base, engine	27′ 10″	28′ 9″	30′ 9″	31′ 11″	27′ 9″	3(
Wheel base, engine and tender	58′ 5″	60′ 9″	56′ 8″	61′ 4″	53′ 8″	5
Diameter of drivers	81″	78″	79″	80″	79″	
Cylinders, number	4	4	4	4	4	
Cylinders, diameter	16″ and 27″	15 1/2 and 26″	15 1/2 and 26″	16″ and 27″	15 1/2 and 26″	15′
Cylinders, stroke	28″	26″	26″	26″	26″	
Valve gear, type	Wals.	Steph.	Steph.	Steph.	Steph.	
Steam pressure, in lb.	200	220	220	205	220	
Boiler, type	Str.	E. W. T.	Str.	Belp.	Str.	E
Boiler, smallest diameter	70″	70 3/4″	70 5/8″	65 5/8″	70 5/8″	
Boiler, height center	113″	111 3/8″	111″	109″	111″	
Heating surface, tubes, in square feet	2,475·0	3,453·6	3,465·0	2,680·2	3,267·0	
Heating surface, firebox, in square feet	180·0	181·1	198·0	181·4	198·0	
Heating surface, total, in square feet	2,655·0	3,634·7	3,663·0	2,861·6	3,465·0	
Heating surface, superheater, in square feet	...	...	...	...	...	
Grate area, in square feet	49·5	56·5	50·3	55·5	50·3	
Firebox, length	108″	108 1/8″	96 1/8″	111″	96 1/8″	
Firebox, width	66″	75 1/4″	75 1/4″	72″	75 1/4″	
Fuel, kind	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	I
Tubes, number firetube	297	388	318	315	390	
Tubes, number superheater	...	...	...	...	...	
Tubes, diameter, firetube	2″	2″	2 1/4″	2″	2″	
Tubes, diameter, superheater	...	...	...	...	...	
Tubes, lentgh	16′ 0″	17′ 0″	18′ 6″	16′ 3″	16′ 0″	
Tender, coal capacity, in tons	10	16	10	12 1/2	10	
Tender, water capacity, in gallons	9,000	8,500	6,000	5,500	6,000	
Weight on drivers ÷ tractive effort	4·53	4·82	4·55	5·0	4·58	
Weight total ÷ tractive effort	8·6	8·63	8·45	8·6	8·35	
Tractive effort × diameter drivers ÷ total H. S.	740·0	513·0	520·0	650·0	548·0	
Total heating surface ÷ grate area	53·8	64·3	73·0	51·6	69·0	
Firebox heating surface ÷ total H. S. %	6·8	5·0	5·4	9·37	5·7	
Weight on drivers ÷ total heating surface	41·5	31·7	30·0	41·0	31·8	
Weight total ÷ total heating surface	78·9	56·8	56·0	70·0	58·0	
Equated heating surface	798·0	1,018·0	1,004·0	845·4	1,013·0	
Equated heating surface ÷ grate area	16·1	17·9	20·0	15·2	20·1	
Tractive effort × diameter drivers ÷ equated H. S.	2,470·0	1,835·0	1,900·0	2,210·0	1,875·0	
Total H. S. ÷ superheating heating surface	...	...	...	...	...	
Cylinder volume, in cubic feet	10·2 (2)	8·93 (2)	8·93 (2)	10·2 (2)	8·93 (2)	
Total heating surface ÷ cylinder volume	262·0	408·0	409·0	280·0	386·0	
Equated heating surface ÷ cylinder volume	78·0	114·0	113·0	83·0	113·0	
Superheated heating surface ÷ cylinder volume	...	...	...	...	...	
Grate area ÷ cylinder volume	4·83	6·27	5·6	5·42	5·6	
Reference in *The American Engineer*	1906, p. 308.	1905, p. 287.	1905, p. 109.	1906, p. 73.	1904, p. 166.	19

(1) Serve tubes. (2) Equivalent simple cylinders. (3) Drummond firebox.

es of recent locomotives.

s and weights.

THAN THE PACIFIC AND PRAIRIE.

				TEN WHEEL (4-6-0).					AMERICAN (4-4-0).		
es.	C. R. I. & P.	G. W. (Eng.).	P. R. R.	D. L. & W.	N. Y. C.	C. & N. W.	Belgium.	L. & S. W.	C. R. R. of N. J.	D L. & W.	L. S. & M. S.
	1,019	40	2,512	1,012	2,099	...	...	330	852	955	Pony.
1.	American.	Great. West.	Soc. Als.	American.	Americ.	American.	Soc.Anon.	L. & S. W.	American.	American.	L. S. & M. S.
	1905	1906	1904	1905	1905	1907	1906	1905	1905	1905	1906
.	Simple.	Simple.	Compound.	Simple.	Simple.	Simple.	Simple.	Simple.	Simple.	Simple.	Simple.
	24,700	25,086	19,530	35,100	31,000	30,900	31,500	25,300	23,120	23,710	15,700
	191,300	166,880	164,000	201,000	194,500	179,500	179,300	163,520	161,300	151,200	126,600
	107,100	88,704	87,850	154,000	148,000	135,500	115,500	114,360	111,300	100,000	85,100
	42,400	40,096	41,250	47,000	46,500	44,000	63,800	48,160	50,000	51,200	41,500
	40,800	38,080	34,900	...	...	...	...	...	...	...	...
	144,000	89,600	132,500	120,000	143,500	139,500	...	99,564	122,200	110,000	105,200
	7′ 0″	7′ 0″	7′ 1/2″	14′ 4″	15′ 10″	14′ 10″	14′ 2″	13′ 4″	8′ 3″	8′ 6″	9′ 0″
	27′ 5 1/2″	27′ 9″	28′ 6 9/16″	25′ 6″	26′ 10 1/2″	25′ 10″	38′ 8 1/2″	26′ 7″	23′ 1 1/2″	24′ 5″	25′ 1 1/4″
	57′ 2″	53′ 6 1/4″	59′ 5″	54′ 1/4″	59′ 2″	57′ 9″	...	53′ 2″	49′ 2″	51′ 5/8″	48′ 4 3/4″
	73″	80 1/2″	80 5/16″	69″	69″	63″	78″	72″	69″	69″	63″
	2	4	4	2	2	2	4	4	2	2	4
	21″	14 1/4″	14·8	21 1/2″	22″	21″	17 1/2″	16″	19″	20″	12 1/2″
			and 23 5/8″								
	26″	26″	25 3/16″	26″	26″	26″	24″	24″	26″	26″	20″
	Steph.	Steph.	Wals.	Steph.	Steph.	Wals.	Wals.	Both.	Steph.	Steph.	Wals.
	185	225	227 1/2	215	200	200	205	175	200	185	180
	Str.	Belp.	Belp.	Str.	W. T.	E. W. T.	Str.	Str.	W. T.	Str.	W. T.
	72″	58 3/4″	59 5/8″	74 5/8″	70 5/8″	66 3/8″	65″	67 3/8″	62 1/4″	61 3/16″	50″
	108″	98″	106 5/16″	116 1/2″	115″	...	110 1/4″	108″	113″	...	78″
	2,227·6	1,988·65	2,435·7	3,156·3	3,124·0	2,808·4	1,494·84	2,210·0	1,838·1	1,947·9	1,326·0
	161·8	154·26	181·1	221·7	202·7	150·8	181·7	517·0 (3)	167·6	190·8	140·0
	2,389·4	2,142·91	2,616·8	3,378·0	3,326·7	2,959·2	1,676·54	2,727·0	2,005·7	2,138·7	1,466·0
	338·0	...	...	...	...	...	419·27	...	...	...	...
	44·8	27·07	33·9	94·8	54·93	46·27	32·4	31·5	81·6	87·54	21·0
	96″	98 1/2″	119 7/8″	126 1/8″	105 1/8″	102 1/8″	118·67″	114″	122 1/8″	126 3/16″	96″
	67 1/4″	38 1/2″	40″	108 1/4″	75 1/4″	65 1/4″	40·55″	45″	96 1/4″	100″	31″
l.	Bit. coal.	Bit. coal.	Bit. coal.	Anth. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Bit. coal.	Anth. coal.	Anth. coal.	Bit. coal.
	173	250	139 (1)	398	400	337	108	340	280	280	187
	54	...	...	...	...	...	25	...	...	...	...
	2″	2″	2 13/16″	2″	2″	2″	2″	1 3/4″	2″	2″	2″
	3 1/2″	...	...	...	...	...	5″	...	...	...	...
	16′ 0″	15′ 2 5/16″	14′ 5 1/4″	15′ 3″	14′ 11″	16′ 0″	13′ 1 1/2″	14′ 4 1/2″	12′ 6″	13′ 4 1/4″	13′ 6 1/2″
	12	...	12 1/2	10	12	10	6 1/2	4·5	12	10	10
	7,000	3,500	5,500	6,000	7,000	7,500	4,400	4,000	5,000	5,000	4,300
	4·2	3·7	3·5	4·38	4·77	4·38	3·66	4·5	4·8	4·22	5·4
	7·8	6·64	8·4	5·72	6·27	5·80	5·7	6·5	6·95	6·4	8·1
	754·0	943 0	600·0	717·0	647·0	655·0	1,470·0	660·0	800·0	765·0	670·0
	53·3	78·8	77·5	35·6	60·5	64·0	51·7	86·5	24·7	24·4	69·5
	6·75	7·2	6·9	6·6	6·1	5·10	12·2	18·6	8·4	8·9	9·5
	44·8	41·4	33·6	45·6	44·5	45·75	68·9	42·0	55·3	46·8	58·0
	80·0	78·0	62·6	59·8	58·7	60·50	107·0	60·0	80·5	71·0	86·5
	718·8	664·26	821·1	1,028·7	1,010·7	852·8	594·7	1,099·0	687·6	722·8	501·0
	16·0	24·5	24·2	10·9	18·4	18·4	18·4	34·8	8·4	8·3	23·8
	2,510·0	3,040·0	1,910·0	2,350·0	2,130·0	2,280·0	4,150·0	1,665·0	2,320·0	2,270·0	1,980·0
	7·08	...	...	...	...	...	4·00	...	...	...	...
	10·4	9·6	7·15 (2)	10·9	11·4	10·4	12·8	11·2	8·6	9·5	5·7
	230·0	223·0	367·0	311·0	292·0	287·0	131·0	244·0	233·0	224·0	257·0
	69·0	69·0	115·0	94·0	88·0	82·0	46·3	98·0	80·0	76·0	87·5
	32·5	...	...	...	...	...	32·8	...	...	...	...
	4·3	2·82	4·72	8·68	4·8	4·45	2·53	2·81	9·5	9·2	3·68
4.	1905, p. 329.	1907, p. 57.	1904, p. 203.	1905, p. 407.	1906, p. 59.	This issue.	1906, p. 220.	1907, p. 183.	...	...	1906, p. 293.

[313 : 385 (.42)]

7. — The chief English railways in 1906.

(*Zeitung des Vereins.*)

The financial year of the English railways coincides with the ordinary year, and a separate report is issued for each half-year. During the last year, nothing special happened on the chief English railways. Generally speaking, receipts increased on account of the improvement in trade, but the expenses rose simultaneously, owing to the higher price of coal and materials, and greater expenditure on maintenance and improvement of roads and rolling stock. Dividends showed an increase in all cases except two. Nearly all the managements complained of electric tramway, motor bus and motor car competition, which led to reduced town and suburban traffic; but this was more than compensated by increase in the long-distance traffic.

The new additions to the system of the Great Western Railway, made during the last few years, led to increased competition for the Welsh and Irish, as well as the Devonshire and Cornwall traffic. The London & North Western Railway records a very satisfactory year; this railway deals with the bulk of the chief industries of the country (coal, iron, wool, cotton, machinery, chemicals, etc.), and conveys much passenger traffic between large towns and the sea coast. The North Eastern Railway effected material economies by increasing the train-loads, with consequent reduction in the train-mileage. Of the four chief railways, the report of the Midland is the least satisfactory; profits were affected by the large sums spent on improving the lines and adding to the rolling stock. The Great Eastern Railway increased the number of their passenger trains and accelerated them; it also records a material increase in mineral traffic. The London & South Western Railway is chiefly a passenger line; it carried a million passengers, nearly all 3rd class, more than in the previous year, whereas 2nd and 1st class showed a decrease; the trans- channel traffic to Havre is developing very satisfactorily. Early in the year it absorbed the Waterloo & City and the Axminster and Lyme Regis railways. The very serious accident at Salisbury occured during the past financial year (1), and the management set aside £30,000 to meet claims. In the previous seventeen and a half years the railway had carried more than 1,220 million passengers, and only 1 was killed. The Great Northern Railway recorded the highest receipts since its inception, but owing to increased expenditure and greater capital outlay the net profit suffered; the company expects a material increase in its suburban traffic owing to the opening of the Piccadilly and Brompton tube. The South Eastern and Chatham Railway records the highest gross receipts since 1900. The progress in the continental traffic and in the goods traffic was very satisfactory, particularly during the first half-year, although the passenger traffic was affected by the collapse of the roof of Charing Cross station. £20,000 were paid as compensation to the adjoining Avenue Theatre. The company expects that the traffic will grow materially owing to the enlargement of Dover Harbour and to the discovery of coal fields in Kent. The Lancashire & Yorkshire Railway shows very satisfactory progress in every way, a better dividend being paid than in 1905. During last year, the hauling power of the locomotives increased 36 per cent, the capacity of the goods stock 30 per cent, and the seating capacity of the passenger stock 18 per cent. The snowstorms about Christmas time caused an expenditure of £20,000. The Great Central Railway shows material progress, particularly if

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(1) Vide *Bulletin of the Railway Congress*, No. 8, August 1906, p. 1341, and No. 10, October 1906, p. 1639.

Index number.	RAILWAY.	Half-year.	Length, in English miles, of railway.	Length, in English miles, of track.	Number of locomotives.	Number of passenger carriages.	Number of goods wagons.	Mileage, in thousands of train-miles.					Receipts per mile of railway, in pounds sterling.	U (1).	Receipts-passenger trains,	Receipts-goods trains,	Generally,	U (1),	Expenses,	U (1),	Excess,	U (1),
								Passenger trains.	Electric and motor trains.	Goods trains.	Total.	U (1).			in pence per mile.							
1	Great Western	I	2,771	4,465	2,400	7,273	65,472	12,732	951	9,782	23,465	+ 1·8	2,120	+ 1·0	47·45	77·76	60·08	+ 0·4	34·34	...	25·74	+ 0·9
		II	2,880	4,643	2,522	7,518	66,823	14,411	1,213	9,787	25,411	+ 3·8	2,307	— 0·8	51·60	80·52	62·74	...	33·42	+ 0·8	29·32	— 1·0
2	London & North Western	I	1,943	3,918	2,570	7,826	75,328	13,730	...	9,551	23,281	+ 5·4	3,660	+ 4·5	49·97	106·85	73·32	— 0·8	42·48	— 7·4	30·84	— 0·9
		II			2,580	7,926	75,583	15,566	...	9,645	25,211	+ 2·5	4,041	+ 2·4	54·41	107·57	74·76	— 0·1	42·48	+ 3·2	32·28	— 1·4
3	North Eastern	I	1,696	3,056	2,000	4,505	100,192	7,103	593	6,073 (2)	13,769	+ 3·5	2,697	+ 6·5	43·31	125·83	79·70	+ 2·9	48·19	+ 3·4	31·51	+ 2·1
		II			2,000	4,538	105,514	8,257	607	6,265	15,129	+ 5·6	2,975	+ 5·3	47·90	125·50	80·04	— 0·2	47·14	— 0·4	32·90	...
4	Midland	I	1,476	3,476	2,790	5,429	117,556	10,681	23	12,616	23,320	+ 4·5	3,901	+ 7·0	40·68	74·98	59·23	...	34·22	...	25·01	...
		II	1,461	3,092	2,790	5,430	117,730	11,629	31	12,730	24,390	+ 1·0	4,210	+ 1·6	43·85	75·82	60·53	+ 0·5	34·13	+ 1·1	26·40	...
5	Great Eastern	I	1,130	1,859	1,085	5,281	26,993	6,178	...	3,814	9,992	+ 0·9	2,232	+ 1·7	53·42	72·17	60·57	+ 0·8	35·01	— 0·3	25·56	+ 2·6
		II	1,135	1,867	1,085	5,283	26,993	6,976	...	4,007	10,983	+ 0·5	2,615	+ 0·3	60·36	72·67	64·85	+ 0·1	34·18	+ 1·6	30·67	— 1·3
6	London & South Western	I	938	1,710	736	4,128	13,705	7,151	110	2,152	9,413	+ 3·8	2,410	+ 1·2	50·90	80·39	57·64	— 2·5	32·27	— 1·5	25·37	— 3·7
		II	943	1,715	743	4,203	13,705	7,498	206	2,204	9,908	+ 2·5	2,663	...	55·61	78·96	60·79	— 2·0	31·37	— 0·6	29·42	— 3·4
7	Great Northern	I	749	1,618	1,279	3,215	38,483	6,246	...	4,754	11,000	+ 5·1	3,212	+ 1·5	38·69	70·63	52·49	— 0·9	32·00	— 1·4	20·49	— 0·3
		II		1,622	1,279	3,246	38,909	6,902	...	4,910	11,812	+ 2·6	3,571	— 0·1	41·78	71·74	54·24	— 0·4	31·86	+ 0·5	22·38	— 1·8
8	South Eastern & Chatham, joint	I	622	1,235	746	4,225	11,419	5,696	27	1,557	7,280	— 0·1	3,344	+ 1·5	64·90	82·30	68·62	+ 1·7	39·10	+ 1·1	29·52	+ 2·5
		II			746	4,262	11,407	6,242	107	1,624	7,973	+ 2·0	3,853	+ 0·4	69·19	83·81	72·17	— 1·5	37·54	+ 0·5	34·63	— 3·7
9	Lancashire & Yorkshire	I	585	1,342	1,378	4,578	31,509	6,086	...	2,674	8,760	+ 3·1	4,732	+ 4·8	44·02	148·10	75·79	+ 1·6	42·15	— 0·1	33·64	+ 4·0
		II			1,378	4,567	31,831	6,830	...	2,725	9,555	+ 4·9	5,131	+ 3·1	47·16	145·73	75·26	— 1·6	40·03	— 1·3	35·23	— 2·0
10	Great Central	I	547	...	994	1,422	26,258	3,678	29	3,980	7,687	+ 3·7	3,314	+ 3·3	33·31	78·31	56·59	+ 4·2	34·65	+ 4·0	21·94	+ 4·5
		II	560	...	1009	1,432	26,361	3,728	40	3,975	7,743	— 1·3	3,462	+ 5·3	38·64	80·45	60·10	+ 6·9	36·76	+ 7·1	23·34	+ 6·5

(1) U. = Percentage increase or decrease compared with corresponding half-year of previous year.
(2) Including the electric goods-train-mileage.

Index number.	RAILWAY.	Half-year.	Receipts.								Expenses	U (1).	Excess.	U (1).	Ratio of expenses to receipts, per cent.
			Passengers.	Parcels and mails.	Goods and cattle.	Minerals.	Steamships and docks.	Rents and miscellaneous.	Generally	U (1).					
			In 100 pound sterling.												
1	Great Western	I	20,999	6,054	15,439	16,248	255	738	59,733	+ 2·3	38,600	+ 2·7	21,133	+ 1·6	64·62
		II	27,240	6,356	16,037	16,795	262	810	67,500	+ 3·8	40,286	+ 4·6	27,214	+ 2·6	59·68
2	London & North Western	I	21,947	6,650	25,501	17,023	...	1,353	72,474	+ 4·4	46,391	+ 4·2	26,083	+ 4·5	64·01
		II	28,065	7,231	26,202	17,033	...	1,458	79,989	+ 2·3	49,818	+ 3·2	30,171	+ 0·8	62·28
3	North Eastern	I	11,241	2,643	15,739	16,100	812	886	47,421	+ 6·6	30,174	+ 6·2	17,247	+ 7·2	63·63
		II	14,723	2,966	16,008	16,758	961	943	52,359	+ 5·5	32,347	+ 4·3	20,012	+ 7·3	61·77
4	Midland	I	13,983	4,161	23,419	15,995	...	914	58,472	+ 4·3	36,825	+ 5·0	21,647	+ 3·2	62·98
		II	16,870	4,437	23,792	16,420	...	1,073	62,592	+ 1·8	38,214	+ 1·8	24,378	+ 0·9	61·05
5	Great Eastern	I	12,072	1,682	8,310	3,159	1,268	837	27,328	+ 1·7	17,811	+ 1·5	9,517	+ 2·1	65·18
		II	15,464	2,082	8,757	3,376	1,570	1,006	32,255	+ 0·8	19,063	+ 1·5	13,192	— 0·1	59·11
6	London & South Western	I	13,036	2,545	4,945	2,261	2,070	537	25,344	+ 1·2	16,433	+ 1·8	8,911	...	64·84
		II	15,009	2,843	5,131	2,119	2,555	705	28,360	+ 0·7	16,765	+ 1·6	11,595	— 0·5	59·11
7	Great Northern	I	8,008	2,061	9,311	4,679	31	421	28,677	+ 4·1	18,751	+ 3·2	9,926	+ 4·8	65·40
		II	9,817	2,202	9,568	5,109	...	514	31,904 [2]	+ 2·3	20,422	+ 3·7	11,482	— 0·1	64·01
8	South Eastern & Chatham, joint	I	13,227	2,250	3,333	2,007	1,214	109	22,140	+ 1·7	14,764	+ 0·3	7,376	+ 4·6	66·63
		II	15,706	2,597	3,654	2,018	1,352	121	25,448	+ 0·6	15,454	+ 1·3	9,994	— 0·4	60·72
9	Lancashire & Yorkshire	I	9,798	1,364	10,226	6,276	21	486	28,171	+ 4·9	16,714	+ 3·4	11,457	+ 7·1	59·33
		II	11,921	1,503	10,309	6,233	...	555	30,521	+ 3·3	18,098	+ 2·3	12,423	+ 4·8	59·29
10	Great Central	I	3,640	1,504	6,934	6,054	1,100	597	19,829	+ 8·0	13,054	+ 7·6	6,775	+ 8·9	65·83
		II	4,410	1,656	7,146	6,178	1,160	752	21,302	+ 5·5	14,068	+ 5·3	7,234	+ 5·9	66·04

(1) Percentage increase or decrease compared with corresponding half-year of previous year.
(2) Including receipts for joint lines.

we remember that in 1900 the working still resulted in a loss. In spite of increased receipts, the net profits are smaller, as large sums have been sunk, and because, as a result of new agreements, more is paid for the use of adjoining lines. It is consequently probable that some time will elapse before fair dividends are paid. On January 1, it absorbed the Lancashire, Derbyshire & East Coast line; a better control over the coal traffic is the consequence and the position of the railway is materially strengthened. In the adjoined table the chief figures are given for both half-years.

[313 .385. (01]

8. — Classifications for mileage statistics and road and equipment expenditures.

(*The Railway Age.*)

The Interstate Commerce Commission has wisely refrained from requiring that no accounts other than those which it prescribes by official promulgation shall be kept by railways. Under the law " the commission may, in its discretion, prescribe the forms of any and all accounts, records and memoranda," and it is made unlawful " to keep any other accounts, records or memoranda than those prescribed or approved by the commission. " The law thus places it within the power of the commission, to distress the railways by limiting accounting operations too strictly. The commission, however, in the orders accompanying the classifications of accounts issued thus far, while protecting the integrity of the general and primary accounts involved, expressly states that any primary accounts may be subdivided as may be required for the purposes of any carrier, receiver or operating trustee, and that the amounts contained in the primary accounts may be assigned to operating divisions, to individual lines, or to states; provided, that a list of such accounts or assignments be filed with the commission subject to disapproval. Although the new accounts must be followed from July 1, it is ordered that to preserve the basis of comparison, carriers may also continue their present accounts for the fiscal years ending June 30, 1908. For the purpose of developing the efficiency of operations, any temporary or experimental accounts may also be kept, although they must be open to inspection by the commission. The fact that the government might prescribe some uniform method of subdividing the primary accounts, or of maintaining experimental accounts, is overweighed by the need and importance of accounting of this character, in order that proper comparison may be secured between the different divisions of a railway and that operating results, through reduction to different units, may be revealed clearly. Professor Adams and the commission have justly recognized the value of analytical accounting which will promote the economy of railway service, and will not impair the integrity of accounts showing general results.

Mileage statistics.

In introducing the " Classification of locomotive-miles, car-miles and train-miles," professor Henry C. Adams, in charge of statistics and accounts for the commission, says that the rules " should be observed by carriers in the adjustment of all entries in operating expense, in operating revenue, or in any other accounts kept by them to which the rules pertain." He adds :

The classification here promulgated was worked out at a conference with accredited representatives of the American Railway Association and of the Association of American Railway

Accounting Officers, and, with a few minor exceptions, embodies the recommendations submitted by them. It may be proper to say that the arbitrary of 6 miles per hour for switching locomotives is accepted temporarily, pending an investigation, the purpose of which is to determine whether or not this arbitrary conforms to the facts. This investigation will be undertaken by the division of statistics and accounts in co-operation with a subcommittee of the committee on "Statistical Inquiry" of the American Railway Association.

The text of the classification, as promulgated, is published in full, as follows :

Revenue service locomotive-miles.

Freight locomotive-miles : Includes miles run by locomotives between terminals or stations with freight trains, also miles run by locomotives between terminals or stations, with or without cabooses, going for or returning from this service; miles run by locomotives while assisting freight trains, either as pushers or double-headers; miles run while hauling the second cut of a freight train doubled over grades; miles run light by locomotives going to or returning from assisting freight trains, as pushers or double-headers; miles run light returning to train after having hauled the first cut of a freight train doubled over grades; miles run light by locomotive of a freight train to and from the next coaling station or water tank for coal or water; miles run light to pick up or assist a freight train at stations between train terminals; miles run to pick up and haul dead freight train locomotives into terminals; also miles run by locomotives coming from or going to engine houses or turntables from freight train service, provided no miles be allowed for this latter service if the distance by 1/2 mile or less in one direction.

Passenger locomotive-miles : Includes miles run by locomotives between terminals or stations with passenger, mail and express trains, also miles run by locomotives going for or returning from this service; miles run by locomotives while assisting passenger, mail and express trains either as pushers or double-headers; miles run light by locomotives going to or returning from assisting passenger trains, as pushers or double-headers; miles run light by locomotives of a passenger train to and from the next coaling station of water tank for coal of water; miles run light to pick up or assist a passenger train at stations between train terminals; miles run to pick up and haul dead passenger train locomotives into terminals; also miles run by locomotives coming from or going to engine houses or turntables from passenger train service, provided no miles be allowed for this latter service if the distance be 1/2 mile or less in one direction.

Mixed locomotive-miles : Includes miles run by locomotives between terminals or stations with mixed trains, also miles run by locomotives between terminals or stations, with or without cabooses or passenger train cars, going for or returning from this service; miles run by locomotives while assisting mixed trains, either as pushers or double-headers; miles run while hauling the second cut of a mixed train doubled over grades; miles run light by locomotives going to or returning from assisting mixed trains, as pushers or double-headers; miles run light returning to train after having hauled the first cut of a mixed train doubled over grades; miles run light by mixed train locomotive to and from the next coaling station or water tank for coal or water; miles run light to pick up or assist a mixed train at stations between train terminals; miles run to pick up and haul dead locomotives from mixed trains into terminals; also miles by locomotives coming from or going to engine houses or turntables from mixed train service; provided, no miles be allowed for this latter service if the distance be 1/2 mile or less in one direction.

Special locomotive-miles : Includes miles run by locomotives in special revenue service, such as locomotives hauling chartered trains, paid for either on the basis of a rate per mile run or a lump sum for the train; circus and theatrical trains run under contracts calling for payments of specified amounts for transportation between designated stations; chartered trains for the federal or state governments, carrying troops, munitions of war, camp outfits, etc ; miles run while assisting special service trains, either as pushers or double headers; miles run while hauling the second cut of a special service train doubled over grades; miles run by locomotives between terminals or stations, with or without cabooses or passenger train cars, going for or returning from special service; miles run light by locomotives going to or returning from assisting special service trains, as pushers or double-headers; miles run light returning to train after having hauled the first cut of a special service train doubled over grades; miles run light by locomotive of special service train to and from the next coaling station or water tank for coal or water; miles run light to pick up or assist a special service train at stations between train terminals; miles run to pick up and haul dead locomotives from special service trains into terminals; also miles run by locomotives coming from or going to engine houses or turntables from special service; provided no miles be allowed for this latter service if the distance be $^1/_2$ mile or less in one direction.

Switching locomotive-miles : Includes miles allowed to locomotives while switching in yards (but not at shops for shop purposes), and allowed to train locomotives for performing switching service at terminals or way stations. (Note A. — Switching miles should be computed at the rate of 6 miles per hour for the actual time engaged in such service in excess of one hour at any one station.) (Note B. — Miles run by switching locomotives helping trains out of terminals, as well as miles run light returning to the yard after such service should be treated as "Freight," "Passenger," etc., according to the class of the train helped.)

Non-revenue service locomotive-miles.

Includes miles run by locomotives in the different classes of service described under "Non-Revenue Service Train-Miles," and, in addition, trial trips of locomotives, to be computed as follows :

a) In case of trains of the freight class or of the passenger class and trial trips of locomotives, locomotive-miles should be the actual miles run by the locomotives.

b) In case of trains of the work class the following rules should be applied : When orders are given to a work train to run to a certain point, to work between certain limits and return, the actual timecard mileage should be allowed between points named in the running order and, in addition, 6 miles per hour for time held between working limits. Work locomotives employed for switching at shops for shop purposes, for spotting cars in gravel pits, working with pile drivers, etc., should be allowed a mileage of 6 miles per hour for the actual time in service.

Rules for computing locomotive-miles.

1. All locomotive-miles made in hauling trains, except in helping and work-train service, should be based on the actual distance run between terminals, to be computed from the official timetable or distance table, as prescribed for train-miles.

2. Helping miles of locomotives should be based on the actual distance made with trains in helping service or in doubling hills.

3. Work-train locomotive-miles should be computed according to the rules prescribed for work-train miles.

4. Light locomotive-miles should be based on the actual distance locomotives run light, or with only a caboose, for the entire distance between terminals.

Revenue service car-miles.

Freight car-miles : Loaded, includes miles run by all loaded freight cars in freight service. Empty, includes miles run by all empty freight cars in freight service. Caboose, includes miles run by caboose cars in freight service.

Passenger car-miles : Passenger, includes miles run by home and foreign passenger cars, combinations of passenger and baggage, passenger and mail, and passenger and express cars, chair and club cars, either in service or deadhead. Sleeping, parlor and observation, includes miles run by home and foreign sleeping, parlor and observation cars, either in service or deadhead. Other passenger-train cars, includes miles run by home and foreign dining, cafe and other cars devoted exclusively to the serving of meals or other refreshments; by home and foreign baggage, combination baggage and express, and combinations of baggage, mail, postal and express cars; by home and foreign mail, postal and express cars; also by milk cars in passenger trains; either in service or deadhead.

Special car-miles : Freight, loaded; freight, empty; caboose; passenger; sleeping, parlor and observation; other passenger-train cars, includes miles run by the foregoing cars under their appropriate classes, in special revenue service as defined in the " Classification of Train-Miles."

Non-revenue service car-miles.

Includes miles run by cars in non-revenue trains as defined in the " Classification of train-miles ".

Revenue service train-miles.

Freight train-miles : Includes miles run by revenue-earning trains to transport freight, which do not regularly include a car or cars devoted exclusively or principally to revenue passenger business; also miles run by trains consisting of empty freight car and of trains consisting of a locomotive and a caboose running light between terminal stations on account of unbalanced traffic or other causes. When milk, express, baggage or other cars are hauled in a freight train, their earnings should be classed as freight earnings GAL 2 — Classifications for mileage statistics — E T C and the miles of the train should be considered as freight train-miles. Freight trains that regularly haul no passenger-service equipment, but transport passengers in a caboose should be classed as freight trains, as should also freight trains temporarily using a passenger car in place of a caboose.

Passenger train-miles : Includes miles run by revenue-earning trains to transport passengers, baggage, mail and express, also miles run by trains consisting of deadhead passenger equipment. When one or more cars other than regular passenger-train cars, such as milk cars, cabooses deadheaded back, etc., are hauled in a passenger train, the miles run by that train should be considered as passenger train-miles.

Mixed train-miles : Includes miles run by revenue-earning trains to transport both passengers and freight in cars, each of which is devoted exclusively to either passenger business or freight business.

Special train-miles : Includes miles run by revenue-earning trains, such as chartered trains, paid for either on the basis of a rate per mile run or a lump sum for the train; circus and theatrical trains run under contracts calling for payment of specified amounts for transportation between designated stations; chartered trains for the federal or state governments carrying troops, munitions of war, camp outfits, etc.

Non-revenue service train-miles.

Includes miles run by trains which are not revenue producing, such as : *a*) of the passenger class : pay trains, official trains, inspection trains for railway commissioners, special trains run to convey fire apparatus for use in saving the company's property from destruction by fire, and trains run to convey employés to and from work; *b*) of the freight class : material and supply trains; and *c*) of the work class : construction trains, trains hauling gravel or other ballast, or engaged in bank widening, ballasting, and other maintenance work; wrecking trains, repair trains, snow plows and flangers.

Rules for computing train-miles.

1. Revenue train-miles should be based on the actual distance run between terminals and computed from the official timetable or distance table, the same as passenger-miles, ton-miles and car-miles.

2. Revenue passenger trains and revenue mixed trains may incidentally carry private cars, official cars, work or service cars, or cars of related classes; and revenue freight trains may incidentally carry cars containing railway material and supplies, or other freight which does not earn revenue; but whole trains of such cars should be regarded as non-revenue trains and classed accordingly.

3. Non-revenue train-miles should be based on the actual distance run between terminals. When work trains are run between terminals and not ordered to work at some specified point or within specified working limits, the actual miles run should be allowed to them, the same as to any other class of trains. When ordered to run to a certain point to work at that point or within specified working limits, the actual miles made while under running orders should be allowed to them, and in addition an arbitrary mileage of six miles per hour for the time working at the point or within the working limits named.

4. Each train and each section of a train run by a separate train crew should be considered a separate train, whether hauled by one or more locomotives for either the whole distance or a part of the distance between the train terminals. There should be nothing added to this distance to cover running from engine house to terminal, doubling hills, running for water, switching or other work at way stations, or for the service of helper or pusher locomotives or the extra locomotives on double or triple head trains.

5. Mileage of trains detoured over foreign roads when hauled by the locomotives and handled

by the crews of the home company should be computed on the basis of miles actually run and classified by the detouring line in its train mileage in accordance with the service performed.

Expenditures for road and equipment.

Regarding all entries in the accounts included in this classification it is ruled that " where the consideration in the transaction show in any entry is anything other than money, the actual consideration must be shown in the entry, and the actual cash value thereof shown in the values columns ".

There are 48 primary accounts in the classification, grouped under three general accounts, " Road ", " Equipment " and " General Expenditures ". In his introductory letter professor Adams says :

In 1897, the interstate commerce commission issued a " Classification of construction expenses " for steam railways, and in 1905 this classification was extended by adding to it a " Classification of equipment expenditures ". At the same time, the word " expenditures " was substituted for the word « expenses » in connection with construction accounts. It will be noted that the title of this first revised issue has been changed to « Classification of expenditures for road and equipment ".

This classification, like the classification of " Operating revenues " and of " Operating expenses ", was revised with the co-operation of the accredited representatives of the Association of American Railway Accounting Officers, and, with the exception of the text of account No. 47, " Interest and commissions ", and of the introduction of account No. 19, " General office buildings and fixtures ", is, in all essential particulars, promulgated in the form in which it was recommended by the association. The essential modification of the title and text of account No. 47 is made necessary by the adoption of the rule that all entries of values in the accounts covered by this classification shall be in terms of cash.

The exact text of the account covering " Interest and commissions " is as follows :

To this account should be charged cash commissions and the actual cash value of other commissions on securities sold; interest, cash commissions, and the actual cash value of other commissions on loans effected and on notes issued for money borrowed for construction purposes or for purchase of equipment; interest on overdue payments to contractors or other creditors; and interest, cash commissions, and the actual cash value of other commissions and exchange on other commercial paper issued for similar purposes. Interest on bonds and other securities, including equipment bonds or car trust notes, paid or accrued during construction and before line is opened for operation, is chargeable to this account. To this account should be credited all interest received on moneys acquired for purposes of purchase or construction of road or equipment.

The primary accounts are as follows :

I. — ROAD.

1. Engineering.
2. Right of way and station grounds.
3. Real estate.
4. Grading.
5. Tunnels.
6. Bridges, trestles and culverts.
7. Ties.
8. Rails.
9. Frogs and switches.
10. Track fastenings and other material.

11. Ballast.
12. Track-laying and surfacing.
13. Roadway tools.
14. Fencing right of way.
15. Crossings and signs.
16. Interlocking and other signal apparatus.
17. Telegraph and telephone lines.
18. Station buildings and fixtures.
19. General office buildings and fixtures.
20. Shops, engine houses and turntables.
21. Shop machinery and tools.
22. Water stations.
23. Fuel stations.
24. Grain elevators.
25. Storage warehouses.
26. Dock and wharf property.
27. Electric light plants.
28. Electric power plants.
29. Electric power transmission.
30. Gas-producing plants.
31. Miscellaneous structures.
32. Transportation of men and material.
33. Rent of equipment.
34. Repairs of equipment.
35. Earnings and operating expenses during construction.
36. Cost of road purchased.

II. — Equipment.

37. Steam locomotives.
38. Electric locomotives.
39. Passenger-train cars.
40. Freight-train cars.
41. Work equipment.
42. Floating equipment.

III. — General expenditures.

43. Law expenses.
44. Stationery and printing.
45. Insurance.
46. Taxes.
47. Interest and commissions.
48. Other expenditures

The orders which accompany the classifications are identical in their provisions with the orders contained in the classifications of operating accounts.

BIBLIOGRAPHIA UNIVERSALIS

COOPERATIVE PUBLICATION OF THE OFFICE BIBLIOGRAPHIQUE INTERNATIONAL, OF BRUSSELS

MONTHLY BIBLIOGRAPHY OF RAILWAYS [1]

PUBLISHED UNDER THE SUPERVISION OF

L. WEISSENBRUCH,

Secretary General of the Permanent Commission of the International Railway Congress.

[016 .385. (02]

I. — BIBLIOGRAPHY OF BOOKS

(September, 1907.)

In French.

07 **385** .15

CATIN (H.), docteur en droit.

État ou compagnies. — Étude sur l'exploitation des che-ns de fer.

Cognac, imprimerie Bérauld. In-8°, 98 pages.

07 **625** .142.2 & **691**

HENRY (E.), professeur à l'école nationale des eaux et forêts.

Préservation des bois contre la pourriture par le sol, les ampignons et les insectes. Recherches sur la valeur com-rative de divers antiseptiques.

Paris et Nancy, Berger, Levrault & C^ie^. In-8° avec 10 plan-es hors texte en phototypie. (Prix : 4 francs.)

907 **351** .757. (02

LAPLAICHE (A.), contrôleur général de l'exploitation com-erciale des chemins de fer.

Manuel du candidat à l'emploi de commissaire de surveil-nce administrative des chemins de fer.

Nancy, imprimerie et librairie Berger-Levrault & C^ie^; Paris, ème maison. 7^e^ édition. In-16, VII-246 pages. (Prix : 50 francs.)

In German.

1907 **656** .256

GOLLMER (E.), Oberbahnmstr. Eisenb.-Telegr.-Werkst.-Vorst.

Die Blocksicherungs-Einrichtungen auf den preussischen Staatsbahnen.

Berlin, Administration der Fachzeitschrift « Der Mechaniker ». 2. Auflage, in-8°, 48 Seiten, 40 Figuren. (Preis : 2.40 Mark.)

In English.

1907 **625** .114

HOUSDEN (C. E.).

Practical earthwork tables.

New York, Longmans, Green & Co. 49 pages, diagrams, tables. (Price : 90 C.)

1907 **625** .123

HOUSDEN (C. E.).

Practical hydraulic (water supply and drainage) tables and diagrams.

New York, Longmans, Green & Co. 10 + 105 pages, diagrams, tables. (Price : $1.25.)

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[1] The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjoinly ith the Office Bibliographique International, of Brussels. (See "Bibliographical Decimal Classification as applied to Railway Science," by Weissenbruch, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

N. B. — The Monthly Bibliography is printed on one side only so that it may be cut up into slips and pasted on labels for catalogues and indexes.

07 **697**. (01

HAW (W. Napier).

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ew York, Putnam. O., 12 + 94 pages, diagrams, tables.
ice : $1.)

1907 **621** .14 (02

STRICKLAND (F.).

A manual of petrol motors and motor cars.

London, Charles Griffin & Co.

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II. — BIBLIOGRAPHY OF PERIODICALS

(August, 1907.)

In French.

Annales des mines. (Paris.)

907 621 .13 & 625 .2 (.73)
nales des mines, mai, p. 505.

APIOT (M.). — Les chemins de fer américains. — tériel et traction. (20,000 mots, 6 tableaux & fig.)

Bulletin de l'Association Congrès international des chemins de fer. (Bruxelles.)

1907 656 .211 (.73)
lletin du Congrès des chemins de fer, n° 8, août, p. 731.

GIESE (E.) & BLUM. — Gares de voyageurs et voies remisage dans l'Amérique du Nord. (16,700 mots fig.)

1907 625 .233
lletin du Congrès des chemins de fer, n° 8, août, p. 777.

WEDLER. — L'évolution de l'éclairage des voitures à yageurs des chemins de fer des États prussien et hessois. ,100 mots, 4 tableaux & fig.)

1907 621 .132.8
lletin du Congrès des chemins de fer, n° 8, août, p. 789.

FRAHM. — Automotrices et trains légers sur les emins de fer anglais. (1,850 mots & fig.)

1907 656 .256 (.73)
lletin du Congrès des chemins de fer, n° 8, août, p. 795.

Rapport officiel sur le block-system et les appareils arrêt automatique aux États-Unis. (4,800 mots.)

1907 621 .33
lletin du Congrès des chemins de fer, n° 8, août, p. 803.

Une ligne électrique du « London & North Western ». ,500 mots & fig.)

1907 313 .385 (.3)
lletin du Congrès des chemins de fer, n° 8, août, p. 810.

Les chemins de fer du monde. (2 tableaux.)

1907 656 .257
Bulletin du Congrès des chemins de fer, n° 8, août, p. 815.

La mise en service de la signalisation électrique définitive à la gare du Nord, à Bruxelles. (2,500 mots & fig.)

1907 621. 132.3 & 621 .132.5
Bulletin du Congrès des chemins de fer, n° 8, août, p. 821.

Locomotives construites en Amérique pour les chemins de fer de l'État italien. (850 mots & fig.)

1907 621 .33
Bulletin du Congrès des chemins de fer, n° 8, août, p. 829.

Train spécial électrique circulant sur le « Lancashire & Yorkshire Railway ». (350 mots & fig.)

1907 621 .133.4
Bulletin du Congrès des chemins de fer, n° 8, août, p. 829.

Appareil fumivore, système Staby, appliqué aux locomotives. (1,150 mots & fig.)

1907 625 .4
Bulletin du Congrès des chemins de fer, n° 8, août, p. 834.

Le projet d'un chemin de fer suspendu à Berlin. (900 mots.)

1907 656 .28 (01 (.42)
Bulletin du Congrès des chemins de fer, n° 8, août, p. 836.

YORKE (H. A.). — Pratique suivie en Angleterre en fait d'enquêtes d'accidents de chemins de fer et d'inspection des chemins de fer. (1,900 mots.)

1907 385. (09.2
Bulletin du Congrès des chemins de fer, n° 8, août, p. 839.

Nécrologie : Le docteur von Oesterlen. (400 mots.)

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Bulletin du Congrès des chemins de fer, n° 8, août, p. 101.

Bibliographie mensuelle des chemins de fer. — Livres. (26 fiches.)

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ulletin de la Société des ingénieurs civils de France. (Paris.)

1907 **621** .14 (01

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MARIÉ (G.). — Formule relative à une condition de bilité des automobiles et spécialement des autobus. 000 mots, 1 tableau & fig.)

Bulletin des transports internationaux par chemins de fer. (Berne.)

1907 **351** .812.1 (.45)

lletin des transports internat. par chemins de fer, août, p. 64.

Loi italienne concernant l'organisation de l'exploitation r l'État des chemins de fer non concédés à des entre- ises privées. (600 mots.)

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De la faculté de refuser d'accepter des marchandises transport pour des raisons d'intérêt public (art. 5, . I.). (2 300 mots.)

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Voiture en acier du Pennsylvania Railroad. (1,700 mots fig.)

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ARAGON (E.). — Le calcul des flèches des poutres ar l'intégration graphique. (3,800 mots & fig.)

1907 **625** .144.4

énie civil, n° 1315, 24 août, p. 280.

Grue roulante pour le ripage des voies employée sur chemin de fer de Colon à Panama. (800 mots & fig.)

1907 **624**. (01

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Appareil enregistreur des flexions et des oscillations des onts métalliques. (1,200 mots & fig.)

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evue universelle des mines, de la métallurgie, des travaux publics, des sciences et des arts appliqués à l'industrie. (Liége.)

1907 **621** .132.3

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CARLIER (J. G.). — Note sur les nouvelles locomotives tlantic des chemins de fer de l'État bavarois et de l'Etat lge. (1,600 mots, 1 tableau & fig.)

In German.

Annalen für Gewerbe und Bauwesen. (Berlin.)

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Annalen für Gewerbe und Bauwesen, Nr 723, 1. August, S. 53.

Akkumulatoren-Triebwagen im Bezirk der Eisenbahndirektion Mainz. (350 Wörter & Abb.)

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Annalen für Gewerbe und Bauwesen, Nr 724, 15. August, S. 65.

MARTENS (H. A.). — Bau- und Betrieb des neuen preussisch-russischen Grenzbahnhofs Skalmierzyce in maschinentechnischer Beziehung. (5 800 Wörter & Abb.)

1907 **625** .245

Annalen für Gewerbe und Bauwesen, Nr 724, 15. August, S. 75.

50 t. Koppel-Selbstentlader. (450 Wörter & Abb.)

Bulletin des internationalen Eisenbahn-Kongress-Verbandes. (Brüssel.)

1907 **385** .61

Bulletin des Eisenbahn-Kongresses, Nr 8, August, S. 719.

Dritte Internationale Konferenz für die technische Einheit im Eisenbahnwesen. (4 200 Wörter, 1 Tabelle & Abb.)

1907 **621** .132.1 (.42)

Bulletin des Eisenbahn-Kongresses, Nr 8, August, S. 737.

ROUS-MARTEN (Charles). — Englische Lokomotiven 1906. Bau und Betrieb. (6 100 Wörter & Abb.)

1907 **656** .211 (.73)

Bulletin des Eisenbahn-Kongresses, Nr 8, August, S. 755.

GIESE (E.) & BLUM. — Personen- und Abstellbahnhöfe Nordamerikas. (13 700 Wörter & Abb.)

1907 **669**

Bulletin des Eisenbahn-Kongresses, Nr 8, August, S. 799.

SUGGATE (Alfred). — Legierungen für Achslager. (5 800 Wörter, 2 Tabellen & Abb.)

1907 **313** .385 (.3)

Bulletin des Eisenbahn-Kongresses, Nr 8, August, S. 815.

Die Eisenbahnen der Erde. (2 Tabellen.)

1907 **621** .132.3

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Verbund-Lokomotive für die Mexikanische National-Bahn. (750 Wörter & Abb.)

907 **621** .134.3
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907 **385**. (09.2
lletin des Eisenbahn-Kongresses, Nr 8, August, S. 834.
achruf : Dr R. VON OESTERLEN. (350 Wörter.)

907 **016** .385. (02
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Monatliches Verzeichnis der Eisenbahnliteratur. — icher. (26 Zettel.)

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lletin des Eisenbahn-Kongresses, Nr 8, August, S. 104.
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RINKEL (R.). — Dampfbetrieb und elektrischer trieb im Snellzugsverkehr. (8 000 Wörter, 5 Tabellen Abb.)

1907 **621** .95
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BRINKMANN. — Die Stosssteinbohrer mit elek- chem Antriebe. (5 200 Wörter & Abb.)

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FELSENSTEIN (F.). — Drei- und Vier-Zylinder-Ver- nd-Schnellzug-Lokomotiven der österreichischen rdwestbahn. (3 400 Wörter, Tabellen & Abb.)

1907 **621** .94
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HOGENMÜLLER (J.). — Drehbank zum Nachrichten von Achssätzen. (800 Wörter & Abb.)

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Organ für die Fortschritte des Eisenbahnw., 7.-8. Heft, S. 155.
. SALLER (H.). — Stosswirkungen im Eisenbahnbetriebe. (3 600 Wörter, Tabellen & Abb.)

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5 000ste Lokomotive der Hannoverschen Maschinenbau-Aktien-Gesellschaft, vormals Georg Egestorff, Hannover-Linden. (500 Wörter & Abb.)

1907 **625** .142.2
Organ für die Fortschritte des Eisenbahnw., 7.-8. Heft, S. 163.
RAMBACHER (A.). — Verbesserungen am Holzquerschwellen-Oberbau. (2 500 Wörter & Abb.)

1907 **62**. (01
Organ für die Fortschritte des Eisenbahnw., 7.-8. Heft, S. 166.
Proben zur Bestimmung der Haftfestigkeit zwischen Beton und Eisen. (300 Wörter, 4 Tabellen & Abb.)

1907 **625** .144.4
Organ für die Fortschritte des Eisenbahnw., 7.-8. Heft, S. 168.
Moorescher Schienenbohrer. (450 Wörter & Abb.)

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1907 **621** .132.3
Schweizerische Bauzeitung, Nr 5, 3. August, S. 55.
WEISS (M.). — Heissdampf-Personenzugslokomotive Serie B 3/4 der schweizerischen Bundesbahnen. (1 700 Wörter, 2 Tabellen & Abb.)

1907 **625** .13
Schweizerische Bauzeitung, Nr 6, 10. August, S. 67.
CRUGNOLA (G.). — Bauausführung des Gattico-Tunnels im Zuge der Santhià-Borgomanero-Arona-Bahn. (1 600 Wörter & Abb.)

1907 **625** .162
Schweizerische Bauzeitung, Nr 7, 17. August, S. 86.
Selbsttätige Sichereitseinrichtungen Oerlikon für Niveauübergänge von elektr. Bahnen. (1 100 Wörter & Abb.)

itschrift des österreichischen Ingenieur- und Architekten-Vereines. (Wien.)

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ZUFFER (J.). — Die offenen Strecken der neuen Alpen-anen. (3 000 Wörter, 5 Tabellen & Abb.)

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DIETZ (W.). — Die Strassenbrücke über den Rhein ischen Ruhrort und Homberg. (4 000 Wörter, 1 Tabelle Abb.)

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WEBER. — Wege und Eisenbahnen. (3 800 Wörter.)

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Zeitung des Vereins, Nr 60, 7. August, S. 925.

Einige Bemerkungen zur Ordnung der Bahnbewa-chung. (2 800 Wörter.)

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GOTTSCHALK. — Die direkte Personen- und Gepäck-abfertigung. (950 Wörter & 2 Tabellen.)

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HEUBACH. — Die Unterhaltung der Eisenbahngleise in den Kurven. (950 Wörter & Abb.)

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BLUM. — Die neue Signalordnung und die einheit-lichen Ausführungsbestimmungen für die deutschen Eisenbahnen. (900 Wörter.)

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Zeitung des Vereins, Nr 64, 21. August, S. 981.

HERTZER (W.). — Die Verfügungsgewalt des Absenders und des Empfängers nach deutschem Eisenbahnfrachtrecht. (2 500 Wörter.)

Zentralblatt der Bauverwaltung. (Berlin.)

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LANG (Ed.). — Weichenverbindung zwischen zwei nicht aus einem gemeinsamen Mittelpunkte beschriebenen Kreisbogengleisen. (550 Wörter & Abb.)

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BLUM. — Neue Signalordnung mit einheitlichen Ausführungsbestimmungen sowie einheitliche Fahrdienstvorschriften für die deutschen Eisenbahnen. (1 700 Wörter.)

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100,000 lb. capacity dynamometer car. (3,200 words & fig.)

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Simple consolidation locomotive. (700 words & fig.)

Bulletin of the International Railway Congress Association. (Brussels.)

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Third international conference of the union for the standardizing of railways. (4,800 words, 1 table & fig.)

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WYSSLING (W.). — Reports of the Swiss commission for studying the electrification of the railways. (7,600 words & 7 tables.)

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GUILLERY (C.). — The coalyard at Cologne station (Eifeltor). (2,000 words & fig.)

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LSON (C.). — The railways in 1905-1906. (Review affic questions.) (6,800 words & 2 tables.)

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Locomotives on the Lancashire & Yorkshire Railway. (1,300 words & fig.)

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The new Stanford bridge, Worcestershire. (1,600 words & fig.)

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A balanced compound locomotive for the Italian State Railroads. (1,800 words & fig.)

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Decapod locomotive for the Buffalo, Rochester & Pittsburg. (1,200 words & fig.)

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The Bothwell locomotive. (350 words & fig.)

1907 **621** .132.5
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Mallet compound locomotive for the Erie Railroad. (1,800 words & fig.)

1907 **621** .33
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McHENRY (E. H.). — Electrification of the New York, New Haven & Hartford. (6,500 words & fig.)

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1907 **621** .133.2
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HANCOCK (E. L.). — Tests of staybolts and staybolt iron. (1,000 words & fig.)

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1907 **621** .132.5
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1907 **625** .173
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Track elevation on the Milwaukee division, Chicago & Northwestern Railway. (1,000 words & fig.)

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Railway Age, No. 1627, August 16, p. 216.

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1907 **625** .232
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The national sleeping car. (500 words & fig.)

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907 621 .332
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The electrification of the Hammersmith & City Railway branch of the Great Western Railway. (5,300 words & fig.)

1907 625 .252. (01
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1907 621 .33
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The overhead construction of the New Haven Railroad. (3,500 words & fig.)

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BLAKEMORE (M. N.). — The Pittsburg & Butler Street Railway Co. (2,200 words & fig.)

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Electric power and lighting and the electrification of the Hammersmith and City Railway. (13,000 words, 1 table & fig.)

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Ingegneria ferroviaria. (Roma.)

1907 **621** .132.5

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Locomotiva a 5 assi accoppiati, compound a 4 cilindri, ruppo 470, delle ferrovie dello Stato. (900 parole & fig.)

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CERRETI (U.). — La ferrovia elettrica di Val Brembana. (500 parole & fig.)

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BOLAND (A. J.). — Eigenaardige zaagsneden van spoorstaven. (1,500 woorden & fig.)

Vol. XXI. — No. 11. November, 1907. 12th Year of the English Edition.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
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(ENGLISH EDITION)

[625 .233]

THE EVOLUTION OF THE LIGHTING OF PASSENGER CARRIAGES ON THE PRUSSIAN AND HESSIAN STATE RAILWAYS,

By Mr. WEDLER,
TECHNICAL SECRETARY OF RAILWAYS, BERLIN.

Figs. 1 to 8, pp. 1086 to 1094.

(*Organ für die Fortschritte des Eisenbahnwesens.*)

The desire to utilize long railway journeys for working purposes, and the fact that the public has become accustomed to very bright, possibly even too bright, lighting, have induced greater and greater demands as regards the lighting of passenger carriages.

At present, if good lighting of passenger carriages is required, the only two systems available are gas and electricity; the rivalry between these two systems is keen and has lasted for years. The Administration of the Prussian State Railway has made and authorized many trials to decide the question. Electric lighting has the advantage that as flexible conductors can be used inside the carriage, special lamps can easily be located in any desired position. Advantage has recently been taken of this property by equipping the saloon carriages, the sleepers and the corridor carriages with electric reading lamps, which the passengers can turn on or off. In each 1st and 2nd class compartment of the corridor carriages, there are, besides the gas roof lamp, four reading lamps on the sides above the seats; each is of 6 Hefner candle-power and placed so that passengers can read in the most comfortable position. The sleeping cars and saloon carriages have reading lamps with flexible conductor and stand to place on the table or fix to the wall. The generating plant and accumulators which supply the current, are carried in the luggage van. These are the main features of this supplementary lighting.

We do not propose here to consider the trains and carriages still in use, equipped with electric lighting only, of various types; there is no intention of extending these experimental applications, for gas lighting, by means of roof lamps, is more economic than electric lighting; it is also more reliable, the light is steadier, and less attention and maintenance are required. An additional factor is the great improvement made in the manufacture of durable incandescent substances; it is now possible to use incandescent gas lighting in railway carriages.

By way of comparison, before proceeding to give details of the new system, we will give a short sketch of the lighting methods formerly used.

The earlier railway carriages had no lighting, although mail-coaches had; the reason no doubt was that in the early days very few trains were run at night. Later on, the railway companies opposed such innovation as long as possible, and lighting only became general in 1845-1846, in consequence of orders issued by the highest authorities (¹).

The original lighting was by means of candles of about 1·2 Hefner candle-power, and cost from 3·4 to 4·4 pfennigs (0·4080*d.* to 0·5280*d.*) per hour; it is now only used, in an improved form, as additional or emergency lighting in saloon carriages and vans. The prime cost and the cost of maintenance are both low (²). Later on, colza oil lamps came into general use; the illuminating power and oil consumption varied with the size of the wick, and amounted approximately to: flat wicks, 2 to 4 Hefner candle-power and 10 to 20 grams (5·6 to 11·2 drams) of oil per hour; round wicks, 3 to 5, and in the most improved patterns 6 to 7 Hefner candle-power, and 20 to 40 grams (11·2 to 22·5 drams) of oil per hour. The illuminating power of these lamps however depended, to a large extent, on the care with which they were cleaned and maintained; hence considerable expense resulted, which was increased by the fact that chimneys frequently became broken. Moreover, maintaining the lamps was a dirty and disagreable job. As a considerable number of lamp cleaners was required, the expenditure may be estimated to amount to at least 4 to 5 pfennigs (0·480*d.* to 0·600*d.*) per hour (³). Petroleum lamps had similar disadvantages; they were less used, and indeed were not allowed to be used in Prussia for lighting carriages owing to the danger from fire. Colza oil is very liable to freeze; a small quantity of petroleum was often added to prevent this.

Gas lighting was a great step in advance; the light is brighter and more reliable, the lamps are always ready for use and are cleaner and require less attention and maintenance, and it is easy to light them.

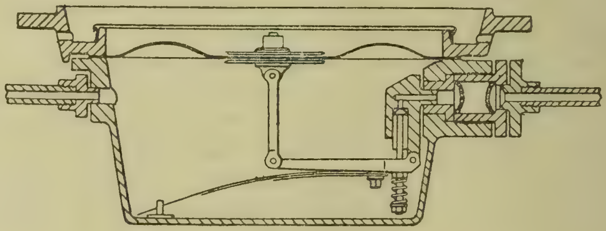

Fig. 1.

The oil gas used loses but little of its illuminating power by compression, and sufficient could

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(¹) *Zeitung des Vereins*, 1906, p. 326.

(²) The average figures given include interest and amortization of prime cost, maintenance, handling, cleaning, cost of candles.

(³) Including, as in the last case, interest and amortization, maintenance, handling, cleaning, cost of oil, wicks and glass chimneys. But we have not taken into consideration the more frequent renewal of cushion and seat covers rendered necessary by oil stains.

be stored under every carriage, under an absolute pressure of 6 atmospheres, to suffice for about twenty-four hours, as soon as a proper form of regulator (fig. 1) had been devised. The same kind of regulator is still used; it consists of a cast iron cup with an elastic diaphragm. This diaphragm is raised by the compressed gas coming from the gas-holders, and actuates a valve which closes when the presssure increases and opens when it diminishes. The constant pressure so obtained varies, according to the number of the burners, between 25 and 55 millimetres (between 1 inch and 2 $^{11}/_{64}$ inches) of water, and may easily be adjusted to any desired value. The *Niederschlesisch-Märkische Eisenbahn* was the first, in 1870, to make trials of oil-gas lighting, and others soon followed. But greater uniformity in the lighting of carriages did not become developed in Prussia until the State purchased the lines, in 1880-1884. The lamp was fitted, as at present, with a two-hole steatite burner; in the 1st and 2nd class compartments the consumption of gas was a little higher, to make up for the greater absorption of light by the coverings of the seats and cushions. The eight-wheeled compartment carriages used since 1896 for express trains, have three-burner lamps in the 1st class compartments, and two-burner lamps in the 2nd class compartments; a few years ago this improvement was extended to all 1st and 2nd class passenger carriages. Photometric determinations of ordinary lamps burning oil gas of average quality gave the following results :

Table I.

TYPE OF BURNER.		No. 40, half-power, for lavatories.	No. 40, for 3rd and 4th class.	No. 50, for 2nd class.	No. 60, for 1st class.	Two burners No. 40, for 2nd class.	Three burners No. 40, for 1st class.
Consumption of gas in litres (in cubic feet) per lamp-hour		15 (0·530)	25 (0·883)	27·5 (0·971)	30 (1·059)	40 (1·413)	50 (1·766)
Illuminating power in Hefner candles. .		4	7·3	8·3	9·4	13	18
Consumption of gas in litres (in cubic feet) per Hefner candle-hour		3·75 (0·1324)	3·42 (0·1208)	3·31 (0·1169)	3·2 (0·1130)	3·07 (0·1084)	2·8 (0·0989)
Cost (1) in pfennigs (in pence) per	100 Hefner candle-hours	12 (1·440)	10·9 (1·308)	10·6 (1·272)	10·2 (1·464)	9·8 (1·176)	9 (1·080)
	per lamp-hour . .	0·48 (0·0576)	0·8 (0·0960)	0·88 (0·1056)	0·96 (0·1152)	1·28 (0·1536)	1·6 (0·1920)

(1) In 1896, a cubic metre of oil gas cost 31 pfennigs (0·1053*d.* per cubic foot); in 1897 this was reduced to 29·77 pfennigs (0·1012*d.*) and in 1898 it rose to 34·51 pfennigs (0·1173*d.*). Average, 32 pfennigs (0·1087*d.*). This figure includes 10 per cent for interest and amortization of capital cost of gas works; it does not include the maintenance and amortization of the carriage equipment, of the gas-holder trucks used for conveying the gas, and of the pipe lines, nor does it include interest on cost of these items. According to an article published in *Glasers Annalen*, 1898, p. 226, this expenditure in 1898 averaged 28·4 pfennigs per cubic metre (0·0965*d.* per cubic foot) of gas consumed; it varies with the magnitude of the annual consumption and of the installation.

In the sleeping cars, saloon carriages and vans of the corridor trains started in 1892, the gas lighting was materially improved, to meet the growing demands, by the use of regenerative lamps, with multiple burners. In these lamps the air required for the combustion is subjected to strong preliminary heating by a system of annular ribs in the lamp. The illuminating power is thereby considerably increased, as shown in table II, which gives a summary of the results obtained by the Berlin Directorate in 1896.

Attempts were made to improve the lighting of the many ordinary carriages by another method, without expensive alteration or renewal of the lamps. A solution of this problem became all the more urgent as the quality of the oil available, and consequently of the gas produced, gradually deteriorated.

Table II.

TYPE OF BURNER.	One, for lavatories.	Two No. 40, for 2nd class.	Three No. 40, for 1st class.
Consumption of gas in litres (in cubic feet) per lamp-hour	20 (0·706)	42·5 (1·501)	60 (2·119)
Illuminating power in Hefner candles	9·5	22	32
Consumption of gas in litres (in cubic feet) per Hefner candle-hour	2·1 (0·0742)	1·9 (0·0671)	1·87 (0·0660)
Cost (1) in pfennigs (in pence) per 100 Hefner candle-hours	6·7 (0·804)	6·1 (0·732)	6 (0·720)
Cost (1) in pfennigs (in pence) per lamp-hour	0·64 (0·0768)	1·36 (0·1632)	1·92 (0·2304)

(1) (See note at bottom of table 1.)

The first attempts made in 1894 to utilize oil gas for the incandescent lighting of railway carriages, by using the mantles which then came into use for coal gas, did not meet with any success. Soon afterwards calcium carbide and acetylene became available; the splendid white light produced by the combustion of the latter led to the undertaking of numerous experiments in order to determine under what conditions it could be used with safety. Pure compressed acetylene was out of the question owing to great risk of explosion. The experiments, carried out with care, showed that oil gas could be mixed, without danger, with up to 30 per cent of acetylene, and that its illuminating power could thus be doubled. The best mixture was found to be : oil gas, 75 per cent; acetylene, 25 per cent. After acetylene works had been added to the existing gas works, the use of this "mixed gas" (*Mischgas*) was adopted generally in 1898-1899. The ordinary gas lamps could be used for this mixed gas without being modified; but the regenerative lamps which gave very good results with gas of low illuminating power, showed a strong tendency to soot up when mixed gas was burnt in them. Consequently they had to be converted into ordinary lamps by removing the regenerative devices. The results obtained in 1898 with mixed gas, consisting of 75 per cent of oil gas and 25 per cent acetylene, and supplied at a pressure of 37 millimetres ($1\,^{29}/_{64}$ inches) of water, are given in table III below.

Later observations showed that burners Nos. 50 and 60, if used for mixed gas, also showed a tendency to soot up; new experiments were accordingly made and the burners were slightly modified; finally the present burners known as Nos. 15, 30 and 40 were definitely adopted. Burner No. 15 is used for lavatories, corridors and vestibules of ordinary carriages; No. 30 for the multiple-burner lamps of all 1st and 2nd class carriages; and No. 40 for all the other single-burner lamps. Finally the reflectors, which were formerly convex, received a concave shape, with consequent better distribution of the light in the compartment. With the same object in view, a few years ago the arrangement was introduced of having, in each 1st and 2nd class compartment, of the eight-wheeled carriages with separate compartments, two separate single-burner lamps at the sides of the roof; the advantage of this arrangement as compared with one single two or three-burner lamp, is not universally recognized. The present gas lamps in the 1st, 2nd and 3rd class compartments also have pull-down shades and cocks for turning down; in the lavatories of all the more recent carriages and everywhere in the corridor carriages and sleeping cars, the lamps also act as air-extractors. In order that the light may be as strong as possible at a convenient reading height (such strength depending on the distance and illuminating power of the lamp), the location of the burners has been uniformly lowered, during the last twenty years, as far as is possible without their getting in the way. The lamps are made of such size that the underside of the glass is 1·96 metres (6 ft. 5 in.) above the flooring. Only in sleeping cars is a greater height given, so that the lamps may not be in the way of passengers using the upper berths.

Table III.

TYPE OF BURNER.	No. 40, half-power, for lavatories.	No. 40, for 3rd and 4th class.	No. 50, for 2nd class.	No. 60, for 1st class.	Two burners No. 40, for 2nd class.	Three burners No. 40, for 1st class.
Consumption of gas in litres (in cubic feet) per lamp-hour	15 (0·530)	25 (0·883)	27·5 (0·971)	30 (1·059)	42·5 (1·501)	55 (1·942)
Illuminating power in Hefner candles	7·5	14	16	18	25	32
Consumption of gas in litres (in cubic feet) per Hefner candle-hour	2 (0·0706)	1·8 (0·0636)	1·7 (0·0600)	1·66 (0·0586)	1·7 (0·0600)	1·7 (0·0600)
Cost (1) in pfennigs (in pence) per 100 Hefner candle-hours	12·2 (1·464)	11·0 (1·320)	10·4 (1·248)	10·1 (1·212)	10·4 (1·248)	10·4 (1·248)
Cost (1) in pfennigs (in pence) per lamp-hour	0·92 (0·1104)	1·53 (0·1836)	1·68 (0·2016)	1·83 (0·2196)	2·59 (0·3108)	3·36 (0·4032)

(1) Calculated under the conditions given above, the cubic metre of mixed gas cost : 54 pfennigs (0·1835*d.* per cubic foot) in 1898; 60 pfennigs (0·2039*d.*) in 1899; 64·52 pfennigs (0·2192*d.*) in 1900; and 62·98 pfennigs (0·2140*d.*) in 1901. Average, 61 pfennigs (0·2073*d.*).

Nevertheless the attempts made to work out a good system of incandescent gas lighting for railway carriages continued; and lately the efforts made to obtain durable mantles have been crowned with success. The Administration of the Prussian State Railway has equipped, as an experiment, several ordinary passenger trains with incandescent lamps with inverted, suspended mantles, after preliminary experiments and trials made on single carriages had made it appear probable that the mantles now made would resist the vibrations and shocks they would be subjected to on trains, for some time. This expectation has now been confirmed by an extended series of trials made under service conditions. Consequently it is intended to equip, with such incandescent gas lighting with inverted mantles, not only all new carriages, but all existing carriages as soon as may be convenient.

As compared with incandescent gas lighting with upright mantle, as adopted by other railway managements, the inverted mantle has, besides its superior appearance, the advantage of greater brightness (¹) and better distribution of the light, as the arm carrying the burner, and the shadow it casts downwards, are both eliminated. These advantages much more than make up for the somewhat longer life of upright mantles, and which is due to the fact that the hottest part of the flame is near the openings of the burner, and that there the destruction of the mantle commences; in the case of the upright mantle, its position is not affected, and it continues to glow, the slight reduction in the illuminating power not being very noticeable; in the case of the inverted mantle, however, the destruction of that part, by which the rest of the mantle is suspended, results in the fall of the mantle. To overcome this disadvantage, the mantles on the carriages of the Prussian State Railway are supported by a small basket made of thin wire (figs. 2 to 4), which prevents its falling if it becomes detached; in such a case it still gives enough light during several days. This little basket also protects the mantle against accidental injury while the glasses and reflectors are being cleaned or when new mantles are put in. New mantles, together with ring and protective basket, are carried on the train, and can be put in, in corridor carriages, while the train is running; in compartment carriages, they can be put in during the next stop. The operation in either case only takes a few seconds. It may perhaps become possible to do away with the basket in the future, if it is discovered how to manufacture stronger mantles.

The lamps have the ordinary construction of incandescent lamps (figs. 5 to 8) (²). The gas comes out of nozzle *a* under an actual pressure of 150 millimetres (5 $^{29}/_{32}$ inches) of water, and becoming mixed with air passes through tube *b* to burner *c*, there is ignited and heats mantle *e*, which is as large as a small walnut and is hung from the magnesia ring *d*. In the upper part of the basket *f*, there is a ring *g*; on the lower edge of the latter, the three-armed magnesia ring of the mantle rests and is held in position by springs. When the roof glass is opened, the reflector *h*, the mantle holder *i* and the mixing tube *b* can be examined and taken out without difficulty, so that all parts are readily accessible and can easily be cleaned. A second tube in the lantern acts as by-pass and feeds the lighting flame *k*, which is at the side of the mantle and can be regulated by the small screw-valve *l*; this is lit at any suitable moment before the main light itself is required. The pipe to the by-pass branches off from the main pipe behind the main valve; this valve or turn-out cock, which was formerly adapted for turning down only, is now arranged so that when it is closed the supply of gas through the main pipe is entirely cut off. In what follows, this cock will be called the cut-off cock. When it becomes dark, and the by-pass flames are burning, all that is required for lighting up the train is to turn on the cut-off cocks of each carriage. The separate turning-down cock of each lamp has been retained, and enables the passenger to turn the supply of gas to the incandescent burner on or off. The by-pass flame continues to burn when the incandescent burner is turned out and gives nearly as much light as did the old gas burner when the light was turned down. The incandescent lamps must not be lit through or from the roof, as owing to the higher pressure of the gas, explosive mixtures of air and gas are more readily formed; explosions in the lamp would be apt to occur. In order to avoid this risk, only the by-pass flames are lit, and from below only; in order to ensure this the upper hoods of the new lamps are fixed on the roof. The same result is obtained with the existing

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(¹) On the French Western Railway, for an equal consumption of gas, used at an equal pressure, the inverted mantle gave a light of 30 candles, as against 20 candles given by the upright mantle.

(²) In figures 7 and 8, the black round object represents a lead seal; this, together with the string to which it is fixed, only serves to secure the basket or the mantle.

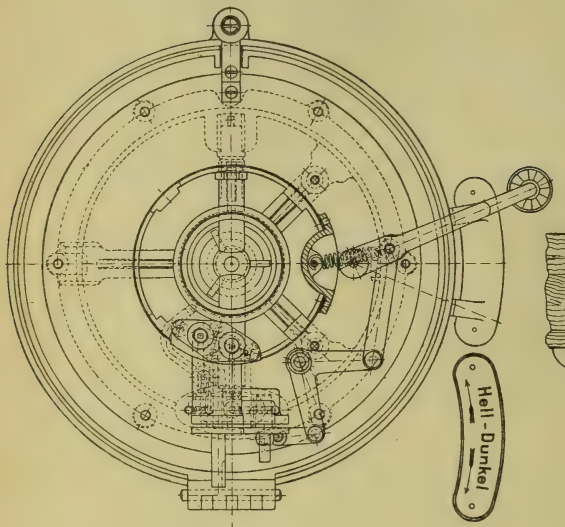
lamps by some suitable device for securing the hoods, for instance copper wire with its ends lead-sealed. There is nothing to prevent the lamps of lavatories and corridor from being used for air-extracting purposes. The chief factor in the success of the new system, apart from the proper manufacture and strength of the mantles, is careful and skilful manipulation by the employees. The quality of the gas used is also of considerable importance. Comparative trials have shown that oil gas alone, and oil gas mixed with a small proportion of acetylene (not exceeding 10 per cent), act less injuriously on the mantles than the usual mixed gas, which contains 25 per cent of acetylene. In the latter case, the deterioration of the mantles is accelerated, not only by the higher temperature of the flame, but also by the impurities contained in the acetylene (phosphorus and silicon). Experiments are at present being made to remove these impurities, by what is known as the " Bavarian purifying process ", from the acetylene before it is mixed with the oil gas. Moreover that the burners, main and by-pass tubes, and reflectors occasionally become sooted up, is also chiefly due to the acetylene. When incandescent lighting has become general, it will therefore be advisable to use unmixed oil gas only, particularly as the light obtained is but little less bright than with mixed gas, as shown by the photometric determinations given in table IV. Besides the two types of mantles I and II, which were used experimentally in the regular service, a third type III was also tried; this however, according to present ideas, is almost too bright for the comparatively limited space of a compartment. But if greater brightness is desired, type III is available.

The table shows that for the same consumption of gas, mantles heated by oil gas give about five times as much light as mixed gas burnt alone, and that the cost per candle-hour is in the latter case about eight times as large as in the former, cost of mantles not allowed for. Unmixed oil gas and mantles give a light but little less bright than mixed gas and mantles, and is materially cheaper, even if the longer life of the mantles is left out of consideration.

The average life of the mantles on the different experimental trains varied a good deal. On a Berlin suburban train, running on the Wannsee line, 81 mantles only became worn out and had to be replaced in 44 lamps used for 118 days and burning on the average 5 hours 56 minutes per day; thus in this case, each mantle had an average life of 64 days, and gave light 380 hours. In this case ordinary mixed gas was used. In the case of an express train on the Berlin-Kattowitz line, where mixed gas was also used, the life of the mantles was a little less than 200 hours; on the Berlin Metropolitan, the life with mixed gas was less than 100 hours, and with oil gas was 134 hours. Whether in the latter case there was any interference or tampering by passengers could not be ascertained. It is to be expected that the consumption of mantles will be reduced as passengers and lamp men become more familiarized with the new system, and, on the other hand, that mantles will become cheaper. At present, a mantle with magnesia ring costs 35 pfennigs (4·2*d.*).

Thus all existing requirements in the way of lighting, can be satisfied by the incandescent gas light with inverted mantle. In spite of the increased light obtained, the gas consumption is materially lower than with the old mixed gas system. As the 1st class compartments now have lamps with three burners, the 2nd class lamps with two burners No. 30, and the 3rd and 4th class lamps with one burner No. 40, there is a saving in gas of more than 30 per cent. When acetylene, which costs 1·48 marks per cubic metre (0·5029*d.* per cubic foot), is no longer used, the cost of the gas consumed will fall from 61 to 32 pfennigs per cubic metre (0·2073*d.* to 0·1087*d.* per cubic foot); and this represents a further economy of 47 per cent. If mantle II is used in 1st and 2nd class compartments, and mantle I in 3rd and 4th and we assume the cost of mantles to equal 0·2 pfennig (0·024*d.*) per lamp-hour (this corresponds to an assumed life of the mantles of

Fig. 2.



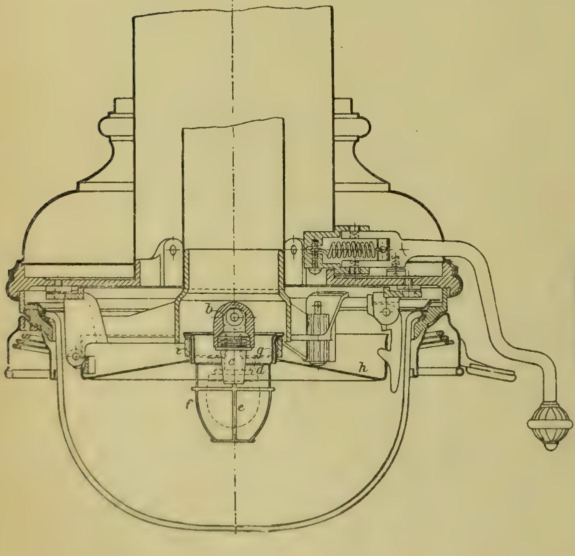


Fig. 3.

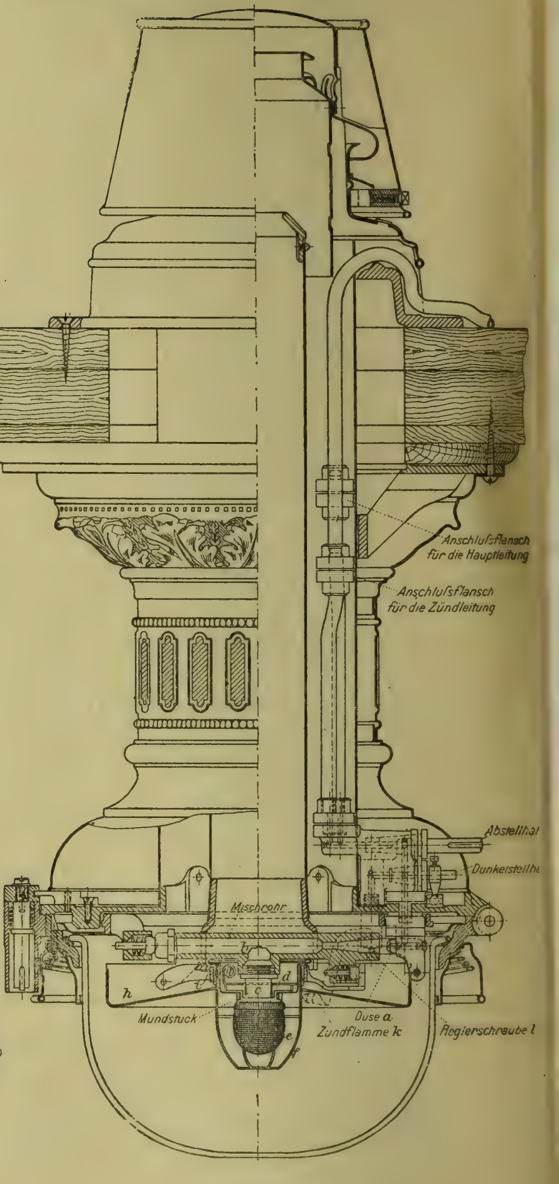


Fig. 4.

Explanation of German terms : Abstellhahn = Cut-off cock. — Anschlussflansch für die Hauptleitung = Union for gas main. — Anschlus flansch für die Zündleitung = By-pass union. — Düse = Nozzle. — Hell-Dunkel = Light-dark. — Mischrohr = Mixing tube. Mundstück = Burner. — Reglerschraube = Regulating screw-valve. — Dunkelstellhahn = Turn-down cock. — Zündflamme = Lighti flame.

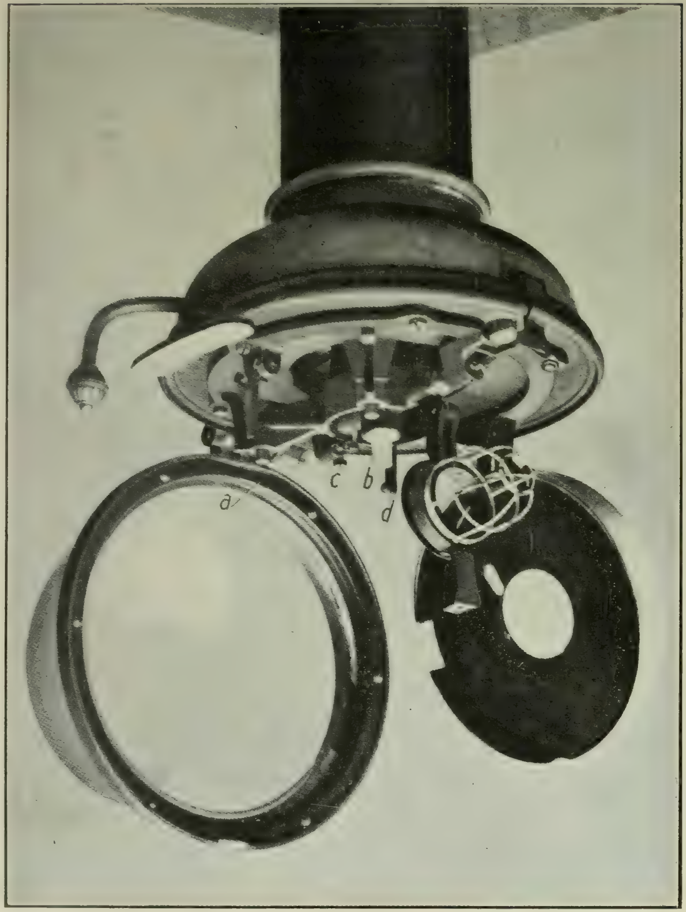


Fig. 5 (1).

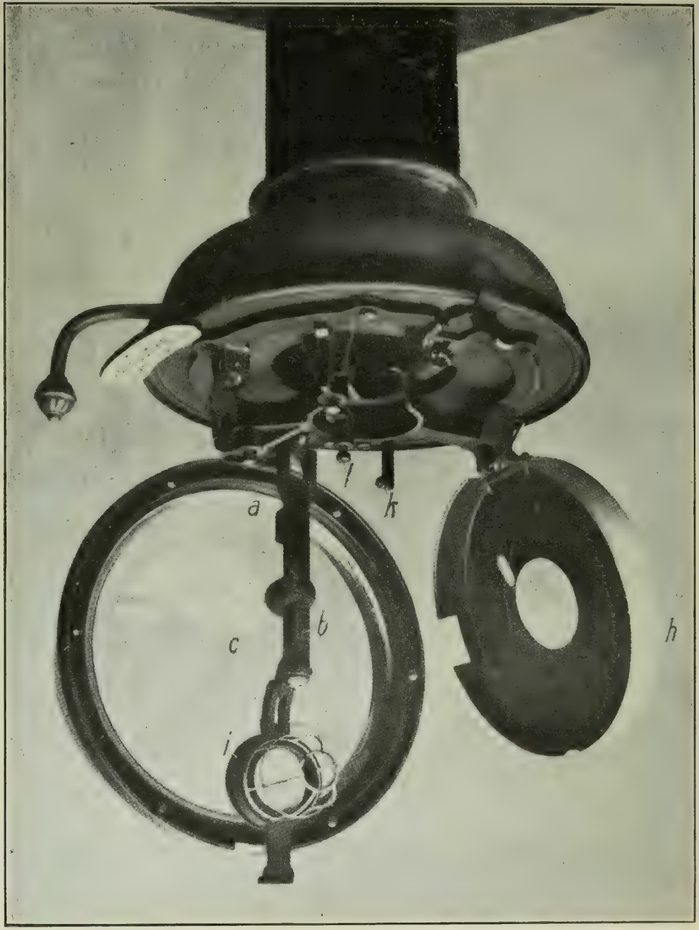


Fig. 6.

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[1] To make the lettering on this figure correspond with the others, replace *b* by *c*, *c* by *l* and *d* by *k*.

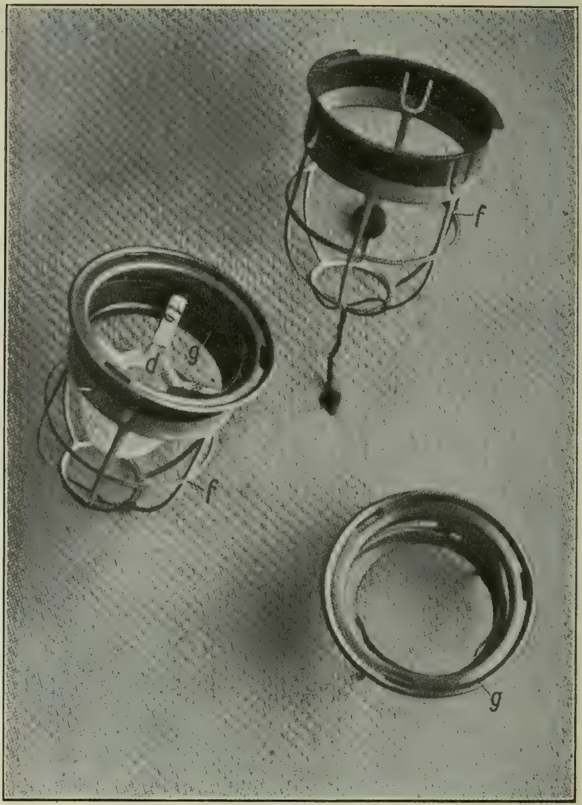


Fig. 7.

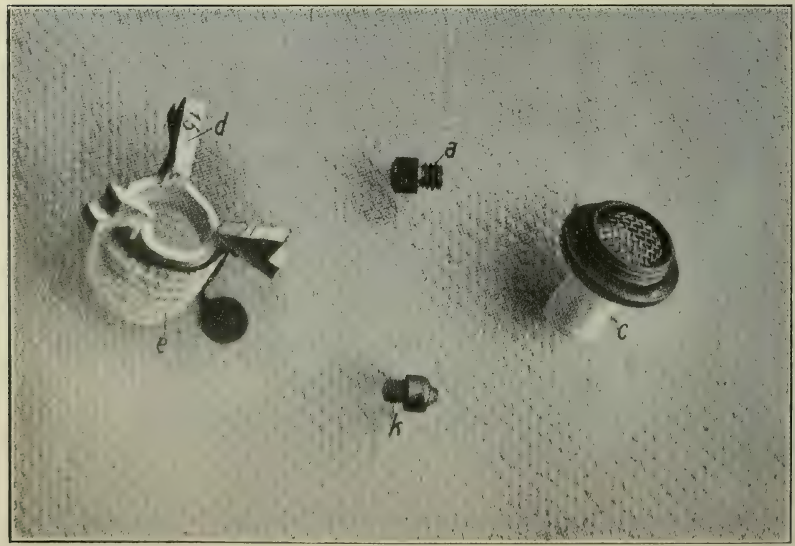


Fig. 8.

Table IV.

—	Present mixed gas lighting, with					New incandescent lighting, with								
	75 per cent of oil gas, 25 per cent of acetylene. One cubic metre costs 61 pfennigs (0·2073*d*. per cubic foot).					Oil gas. One cubic metre costs 32 pfennigs (0·1087*d*. per cubic foot).			Mixed gas. 90 per cent of oil gas, 10 per cent of acetylene. One cubic metre costs 43·6 pfennigs (0·1481*d*. per cubic foot).			Mixed gas. 75 per cent of oil gas, 25 per cent of acetylene. One cubic metre costs 61 pfennigs (0·2073*d*. per cubic foot).		
	One burner			Two burners	Three burners	Type of mantle			Type of mantle			Type of mantle		
	No. 15.	No. 30.	No. 40.	No. 30.	No. 30.	I.	II.	III.	I.	II.	III.	I.	II.	III.
Consumption of gas in litres (in cubic feet) per lamp-hour.	15 (0·530)	25 (0·883)	27 (0·954)	42·5 (1·501)	55 (1·942)	18 (0·636)	26 (0·918)	33·5 (1·183)	18 (0·636)	26 (0·918)	33·5 (1·183)	18 (0·636)	26 (0·918)	33·5 (1·183)
Illuminating power in Hefner-candles.	5·5	12·5	13·8	21·5	27·6	43·3	59·2	74·5	46·2	66·3	84·3	51·5	76·2	97·9
Consumption of gas in litres (in cubic feet) per Hefner candle hour	2·73 (0·0964)	2·00 (0·0706)	1·95 (0·0689)	1·98 (0·0699)	1·99 (0·0703)	0·42 (0·0148)	0·44 (0·0155)	0·45 (0·0159)	0·39 (0·0138)	0·39 (0·0138)	0·39 (0·0138)	0·35 (0·0124)	0·34 (0·0120)	0·34 (0·0120)
Cost in pfennigs (in pence) per 100 Hefner candle-hours . .	16·65 (1·998)	12·2 (1·464)	11·9 (1·428)	12·08 (1·450)	12·14 (1·457)	1·34 (0·1608)	1·41 (0·1692)	1·44 (0·1728)	1·7 (0·2040)	1·7 (0·2040)	1·7 (0·2040)	2·14 (0·2568)	2·08 (0·2496)	2·08 (0·2496)
Cost in pfennigs (in pence) per lamp-hour . .	0·92 (0·1104)	1·53 (0·1836)	1·65 (0·1980)	2·59 (0·3108)	3·36 (0·4032)	0·58 (0·0696)	0·83 (0·0995)	1·07 (0·1284)	0·78 (0·0936)	1·13 (0·1356)	1·46 (0·1752)	1·1 (0·1320)	1·59 (0·1908)	2·05 (0·2460)

only 175 hours), then the cost of lighting a 1st class compartment, by the oil gas and incandescent mantle system, will not amount to quite 33 per cent of what it cost formerly, although the light is more than twice as bright. In the 2nd class, this figure will be 40 per cent, for nearly three times the light; and in the 3rd class, under 50 per cent, for more than three times the light. As against this continuous saving, the only item is the one expense of altering the lamps; this can be spread over a number of years. It will only be necessary to replace old short lamps with fixed glass by new lamps in those few cases where the alteration of the old lamps would not pay. The existing gas equipment of the carriages, the oil-gas works and other gas installations and gas-holder trucks can be utilized as before; hence the vast economic superiority of this system of lighting over all other systems, which can also not equal it in brightness, inasmuch as this can be largely increased by the use of larger mantles.

[621 .133.5]

TRIALS WITH CHIMNEYS AND BLAST-PIPES ON LOCOMOTIVES,

By E. HÖHN,

ENGINEER, BIEL.

Figs. 1 to 4, pp. 1098 and 1099.

(*Schweizerische Bauzeitung.*)

The unsatisfactory steam production of a superheated steam locomotive induced the Swiss Federal Railway, in autumn 1905, to make a series of experiments at its Biel workshops on the most suitable form of chimney and blast-pipe. It was found that the best arrangement then tried was a chimney with a lower cylindrical end, but with its upper end forming an expanding cone of gentle taper, and a blast-pipe reaching up to about the centre line of the boiler, and of as large a diameter as possible.

The high coal consumption of some tank locomotives (series $E^c\,{}^3/_4$-Zwilling) led to a further examination of this question in 1906. The original arrangement adopted at the works is shown in figure 1. After the first trial with this shape, the chimney was extended downwards as shown in figure 2, and the trials with the different forms of blast-pipes were made; these trials were divided into two series. In the first, the blast-pipe used was of the original shape, but shorter and larger; in the second, a tapered form of blast-pipe was used. The instruments employed to check the trials, which were made in the course of the ordinary service, were : a U-shaped water gauge to measure the vacuum in the smoke-box and a similarly shaped gauge connected with the exhaust of one of the cylinders, to measure the back pressure of the exhaust steam. The intention was to determine the best dimensions for a blast-pipe empirically. The results are summarized in the table and in figures 3 and 4, and the following results were arrived at :

The upper limit of size of a nozzle-shaped blast-pipe is already exceeded in No. 9, where the pipe had a diameter of 140 millimetres ($5\,{}^1/_2$ inches) and the actual opening one of 150 millimetres ($5\,{}^{29}/_{32}$ inches); too little steam was generated. In figure 3, in which according to Leitzmann's proposal (¹) the vacuum is represented as a function of the cut-off, per cent, multiplied by the speed, curve 9 is also near the bottom.

(¹) Supplement to *Organ für die Fortschritte im Eisenbahnwesen,* 1906, p. 350.

In the case of the shorter blast-pipe as ordinarily used, it was also found that a diameter of 140 millimetres (5 $^1/_2$ inches) at the orifice formed the practical limit. In the three trials 5, 6 and 7 the cylindrical or conical blast-pipes were so much shorter that the orifice was about 200 millimetres (8 inches) below the centre line of the boiler; in 5 and 6 the action was irregular and many sparks were thrown out; in 7 not enough steam was generated. Moreover, in 5, 6 and 7 the combustion was irregular; it was less at the back of the grate than at the front. The shortened shape proved unsatisfactory. The best results were obtained, firstly in experiment No. 4 with nozzle-shaped orifice with pipe having a diameter of 135 millimetres (5 $^5/_{16}$ inches) and opening having one of 145 millimetres (5 $^{11}/_{16}$ inches); secondly in experiment No. 2 with the old blast-pipe, but made shorter, with the opening of 125 millimetres (4 $^{29}/_{32}$ inches) diameter increased to 140 millimetres (5 $^1/_2$ inches) (an increase of cross-section of 9 per cent). In both cases, the opening is approximately at the same height as the centre line of the boiler (see fig. 2). In both cases, a sufficient and regular draft was produced; there was no jerkiness, the combustion over the whole of the grate was uniform and sufficient steam was generated. In figure 3, curve 4 is in the middle and curve 2 quite at the bottom; figure 4 shows that the back pressure is moderate or very small.

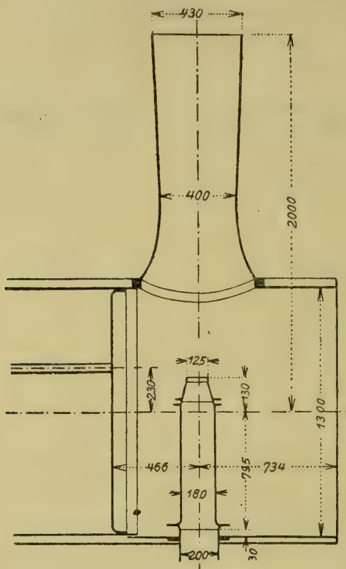


Fig. 1. — Original arrangement of blast-pipe (trial 1 of annexed table).

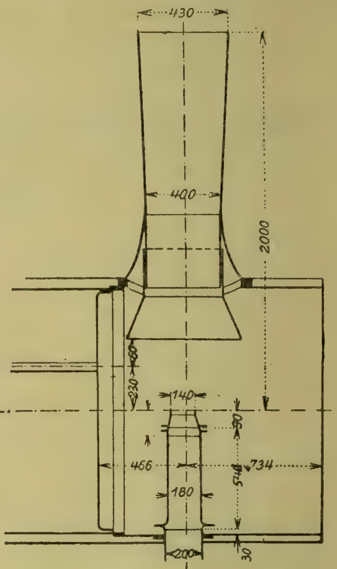


Fig. 2. — Chimney extended downwards and shorter blast-pipe (trials 2 to 9 of table).

As compared with the original arrangement shown in figure 1 (experiment No. 1), in which sufficient steam was also generated, but in which there was also much jerkiness and a very high back pressure, there is a manifest improvement; this also shows itself in the reduced coal consumption.

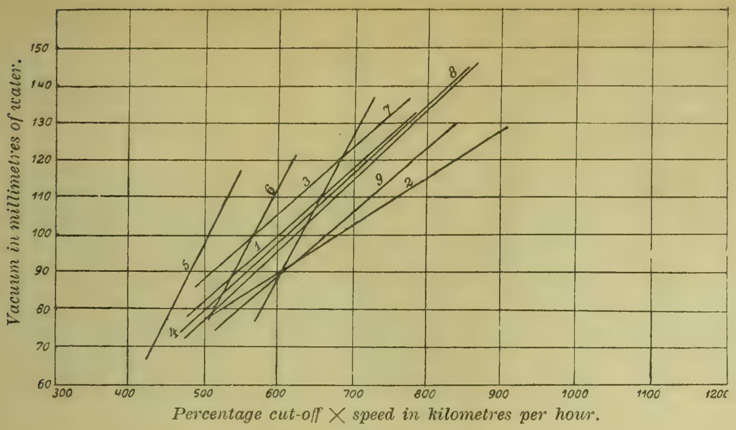


Fig. 3.

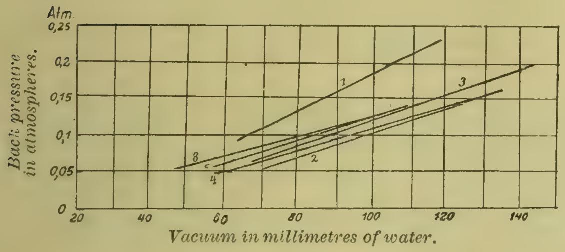
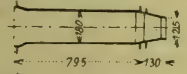
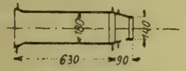
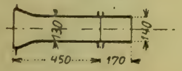
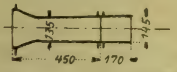
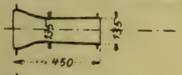
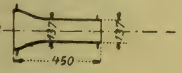
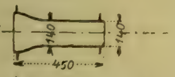
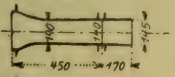
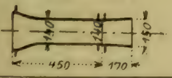


Fig. 4.

Summary of the results of the trials.

(*N. B.* — Trial 1 is with blast-pipe as arranged in figure 1, trials 2 to 9 with it arranged as in figure 2.)

Shape of blast-pipe	Generation of steam	Formation of cinders	Ejection of sparks
Trials. Nº 1 	good.	normal.	considerable with late cut-off.
2 	considerable, better than in 1.	slight.	fairly considerable with late cut-off and high speeds.
3 	good, but somewhat less than in 2.	greater than in 2.	considerable, more than in 1 and 2.
4 	good, but somewhat less than in 3.	a little greater than in 3.	less than in 3.
5 	sufficient for moderate power, weak for express trains.	smaller forwards than in 3 and 4.	with late cut-off and high speeds greater than in 3 and 4.
6 	like 5.	like 5.	somewhat less than in 5.
7 	like 5.	like 5 and 6.	fairly considerable with late cut-off and high speeds.
8 	fairly considerable.	normal.	like 3 and 4.
9 	insufficient for high power.	normal.	smallest, only appears when power is great.

Summary.

When the length of the chimney was increased, the draft produced by the steam was also increased. The pressure above the upper opening of the chimney, as far as its reaction on the production of a vacuum in the smoke-box is concerned, is better overcome by a long column of steam and smoke, than by a short one. Wide chimneys with a contracted part are to be preferred to narrow cylinders.

When long chimneys are used, the orifice of the blast-pipe can be as low as the centre line of the boiler; the gases then tend to come more through the middle or lower tubes. To go much lower is not advisable, as too many sparks are then ejected.

The von Borries formula for the diameter of blast-pipes

$$D = 0{\cdot}156 \sqrt{\frac{S \cdot R}{S + 0{\cdot}3\,R}},$$

where S = cross-section of smoke-tubes in square metres, R = the grate area in square metres, gives very small cross-sections and consequently strong back pressure and jerky action in the smoke-box. When long chimneys are used, the nozzles can be larger; this eliminates the disadvantages mentioned and a constant draft is produced. The efficiency of the engine is somewhat improved by the reduction of the back pressure.

In these trials, the tapered form of blast-pipe did not prove superior to the ordinary shape, but approximately equal. The experiments could however not be carried out with such accuracy and uniformity that they can be considered conclusive. One advantage of the tapered shape is that the locomotive crew cannot tamper with it as easily as with the ordinary shape.

Correct design of chimney and blast-pipe is of considerable importance owing to its effect on the coal consumption.

[385. (09.3 (.494)]

SILVER WEDDING OF THE ST. GOTHARD RAILWAY,

By W. BERDROW.

(*Zeitung des Vereins.*)

On May 22, 1882, the first inaugural train was run, from Lucerne to Milan, over the track of the St. Gothard Railway, which had just been completed; the regular service was set in operation June 1. Thus this great international work has now served the interests of peaceful traffic for twenty-five years. The history proper of the undertaking however extends over more than half a century (¹). It begins on September 3, 1853; on this day, three of the cantons signed, at Lucerne, a document in which they mutually agreed to take joint action to promote the construction of a St. Gothard line. At first this action was rather desultory, but it received a strong stimulus when the questions of a Mont Cenis line, in France, and of a Brenner line, in Austria, began to be seriously considered; for then it became a question of vital importance to Switzerland. This outside stimulus had in a way a happy result, for it alone made an agreement between the Swiss cantons possible. Up till then, eastern Switzerland had been asking for a Luckmanier line, and western Switzerland for a Simplon line; it was then recognised that for the traffic, such as it was, the one line would be too near the Brenner and the other too near the Mont Cenis, and an agreement was readily arrived at that the St. Gothard, located about halfway between, would be the line with the best future. The preliminary operations we do not propose to refer to; we will merely remark that had it not been for the wars of 1866 and of 1870-71, which delayed the progress of the international negotiations, the work would no doubt have been completed sooner. It is on the other hand evident that the participation of Germany, which largely contributed to the success of the enterprise, was impossible until after the victorious war against France and the unification of the empire.

The St. Gothard Railway Company was formed on December 6, 1871; the intention was to construct a double-track main line between Flüelen and Biasca, and three single-track connections, on the north side with Lucerne and Zug, and on the south side with Chiasso or Locarno. A further agreement made 1878-79 specified,

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(¹) See R. Bechtle : *Die Gotthardbahn, ihre Entstehung, Verwaltung, Bau und Betrieb.* 1895, Stuttgart, Konrad Wittwer.

as then already a deficit of 90 million francs (£3,600,000) appeared probable, that the main line should at first be constructed as a single-track line, and that the subsidies contributed by Switzerland, Germany and Italy should be increased to 28, 30 and 55 millions of francs (£1,120,000, £1,200,000 and £2,200,000) respectively. The main tunnel was to be constructed, from the beginning, for a double-track line; the northern line of access, Lucerne-Immensee, was, however, not to be built immediately, as Switzerland had undertaken that by the time the tunnel was open to traffic the connection between Immensee on the one hand, and Lucerne and Zurich on the other, should be made by the lines of the Swiss North Eastern and the Aargau Southern. Among the many men who have contributed to the success of the undertaking we must more especially mention Dr. Alfred Escher, of Zurich, and councillor Zingg, of Lucerne, who subsequently became chairmen of the board.

As regards the design and construction of the St. Gothard Railway, we will here refer only to a few specially interesting points. The 11 kilometre (6·8 miles) section from Brunnen to Sulzegg (near Flüelen), with its alternations of open track and tunnel, of light and darkness, is well known; nearly half of it is in the ten tunnels which succeed each other closely. The continuation to Erstfeld and the steep subsequent ascent on the right side of the valley to Amsteg, show no special features, whereas the further 24 kilometres (15 miles) to the entrance of the great tunnel required no less than seventeen tunnels. The Maderan valley is crossed on a high viaduct; immediately beyond this, the line passes under the Bristenlaui valley, which is dangerous on account of avalanches, but the line is protected by being in a tunnel. Then the line approaches the Reuss, and crosses near Inschi to the left bank by a steel bridge 74 metres (242 ft. 9 in.) high and having a span of 76 metres (249 feet). This is the largest span to be found on the line. Up to here the railway, with an average gradient of 22 to 26 per mil, rises relatively to the bottom of the valley, as the average fall of the Reuss between Amsteg and Flüelen is only 5 to 6 per mil. But here the valley becomes steeper, the gradients varying between 37 and 100 per mil, and the relative height of the railway is rapidly reduced. Already at 7 kilometres (4·3 miles) beyond the Inschi bridge across the Reuss the river is nearly at the same level as the road bed, and the line would have to go either below the river bed or have some scheme provided by which it would gain in height. At Pfaffensprung there is a great helix, 1,476 metres (1,614 yards) of it being in a tunnel; by means of this helix the line rises 51 metres (167 ft. 4 in.) while describing a circle 2,130 metres (1 mile 370 yards) in circumference, and a point is reached, near Wasen, where the line is again 12 metres (39 ft. 4 in.) higher than the river. Then come 8 kilometres (5 miles) of line on the left side of the valley, in three sections; this is a section which for boldness of design and rapid succession of constructional works, is perhaps as yet unequalled. Then there is the Mühl tunnel, the lower Mayenreuss bridge, and the Kirchberg tunnel, and the line then passes through the Wattingen helical tunnel, crosses the Reuss twice and passes under the avalanche-swept couloir of the Rohrbach valley. Wasen station is quite close to the high road, and is 49 metres (161 feet) above the lower and 82 metres (269 feet) below the upper turning place. Immediately at the exit from the station the train enters the covered way which passes under the Entschig valley, where there is danger of avalanches, and then crosses the Mayenreuss a second time, by a bridge 71 metres (233 feet) high.

Then there is another open section, with continuous maximum rising gradient; the line then passes under a small projecting rock and enters the Leggistein tunnel, which has a sharp curve. After leaving the tunnel, the line crosses the Mayenreuss for the third time, passes through the Mayenkreuz tunnel about 150 metres (492 feet) above the Reuss, passes below the avalanche couloir of the Entschig valley, then crosses the Kellerfels ravine a second time by means of a viaduct 90 metres (295 feet) long and finally crosses the Rohrbach (under which it had previously passed) by a metal arch bridge, 60 metres (197 feet) long; the lower opening of the Naxberg tunnel (which is 1,570 metres [1,717 yards] long) marks the end of this section, which is the most remarkable section of the St. Gothard line. The distance between this tunnel opening and the lower opening of the Pfaffensprung tunnel is not more than 3 kilometres (1·86 miles), measured in a straight line; but the actual length is 11 kilometres (6·8 miles), for a rise of 260 metres (853 feet). The Naxberg tunnel passes under three valleys, where there is danger of avalanches; several other couloirs where avalanches may fall, are then crossed by means of bridges, and then there is a bridge, 50 metres (164 feet) high, across the Göschenreuss, which is the last constructional work on the north side. The line then enters the great tunnel at a height of 1,109 metres (3,638 ft. 7 in.). The total length from Flüelen to this point, is about 39 kilometres (24 miles); 7,294 metres (4 miles 254 yards) are in tunnels and 1,300 metres (1,422 yards) on bridges and viaducts.

As regards the construction of the tunnels, it remained understood, even after it had been decided to build the line as a whole on a single-track, that the St. Gothard tunnel and the Tessin valley tunnels were to be made large enough to accommodate two tracks. The other valley tunnels were to be for single-track lines only, and the tunnels for the two great ascending lines of access were to have cross-sections on the Pressel-Kaufmann system. According to this system, the sections in hard rock, where no internal lining was necessary, were made of single-track size, and any enlargement was postponed to the future. But where an internal lining was necessary, the tunnel was at once made of the full size wanted for two tracks, as subsequent enlargement would be difficult. Consequently, the main tunnel was at once built of the full section, and lined with masonry; the work was carried out with the greatest energy, at first by the Genevan contractor Louis Favre, and after his sudden death in the tunnel (July, 1879) by his successor, the engineer Rossi. The main headings met February 29, 1880, and trains could be run in the tunnel itself by January 1, 1882. The masonry lining had not been everywhere constructed with the necessary care; in the interests of safety, it became necessary to do some repairing work, and this continued until 1885. Favre himself fell a victim to the construction of this tunnel, the greatest and most difficult so far attempted; he lost his life and his fortune, and in a subsequent law-suit, by his heirs, no such compensation was recovered as had been expected. The management of the St. Gothard Railway, however, of their own free will granted a pension of 10,000 francs (£400) per year, for life, to the only daughter of Favre. If, however, the construction of the St. Gothard tunnel was eminently unprofitable for the contractor, it may be recalled that, in the case of the Simplon tunnel, everything was done differently. In the case of the St. Gothard, the temperature was so high that both men and animals were largely incapacitated for work; but in the case of the Simplon, the

Brandt system of ventilation, by a parallel heading, reduced the temperature so much that much more work could be done. Moreover, the hydraulic drills had a greater efficiency than the air drills used in the case of the Mont Cenis and the St. Gothard, and helped to cool the working surface. Moreover, the so-called Belgian system adopted at the St. Gothard (start with heading in top, finish with heading in bottom) may have been an unexpected source of increased expenditure. The opposite system was adopted in the case of the Simplon tunnel.

The St. Gothard tunnel, which is nearly 15 kilometres (9·3 miles) long, took a little less than nine years to build, the average number of men at work being 2,480; the clear cross-section is 8 metres (26 ft. 3 in.) wide and 6 metres (19 ft. 8 in.) high; the thickness of the masonry lining is about 40 centimetres (1 ft. 3 ³/₄ in.) where the rock is hard, and 90 centimetres (3 feet) where it is soft. Every 100 metres (109 yards) there is a man-hole in the wall, and every 1,000 metres (1,090 yards) there is a little room to accommodate the electric and telephonic gear. In the middle of the tunnel, and at 4 kilometres (2·5 miles) from each end, there are larger rooms where trucks and platelayers' materials for repairing the line can be stored, and where the platelayers can rest during the intervals between their work. Two watchmen are continually walking through the tunnel; each looks after one half and they meet in the middle.

The line giving access to the tunnel from the south, at first goes along the bottom of the valley as far as Dazio Grande; then up to Faido there is the first gorge of the Tessin valley, and there are two large helical tunnels and six other smaller tunnels, total length 4·3 kilometres (2·67 miles). Then the road-bed once more continues for a short way up the bottom of the valley, which has here a comparatively small rise; then between Lavorgo and Giornico, which are only 7 kilometres (4·3 miles) apart, there is again a bad part of the Tessin valley, where there are again two helical tunnels and two other tunnels, total length 3·6 kilometres (2·24 miles). Taking it altogether, between Giornico and the mouth of the great tunnel, the total length of line is 35 kilometres (21·7 miles); there are thirteen tunnels, four of which are 1,500 metres (1,640 yards) or more in length; the Tessin is crossed five times, and there are bridges over many minor torrents; the difference in height is more than 700 metres (2,296 feet). The other lines to the south go down the valleys, or along the shores of the lakes, and do not show anything particularly remarkable from the technical point of view, except the Bellinzona (Giubiasco) to Lugano line, of later date, which goes through a tunnel 1,675 metres (1,832 yards) long under Monte Cenere. It should, however, be mentioned, that the Brandt hydraulic drill, which subsequently supplanted nearly all the other types, was already tried at the St. Gothard and gave better results than air-drills. Whereas the old machines were used for all the other tunnels of a certain length, the hydraulic drill invented by the former locomotive engineer of the St. Gothard Railway, A. Brandt, was used for the first time for the bottom heading of the Pfaffensprung tunnel, and very soon it was found that, in this hard rock, the hydraulic drill worked at nearly twice the rate, and the bottom heading soon caught up and passed the top heading where the old system was being used. Taking the whole St. Gothard Railway together, it is 240 kilometres (149 miles) long, and has sixty-four tunnels, and sixty-five large bridges and viaducts having altogether a total length of 45 kilometres (28 miles). This railway was in fact of a magnitude of conception and technical execution which had hitherto not been approached, and which the Simplon railway, in spite of its longer tunnel, does not equal, much less surpass.

After these technical particulars, a statistical summary of the commercial evolution of the St. Gothard traffic during the past five and twenty years, may be not without interest. Before the railway was built, the coaches conveyed on the average 70,000 passengers per year across the St. Gothard; the railway from the start conveyed at least three times that number, and goods traffic was at once plentiful. We know that in the case of the Simplon tunnel also, although it has only been open to traffic for a short time, the passenger traffic has been very satisfactory, whereas the goods traffic has been very disappointing. It is true that this is said to be partly the fault of deficiency of Italian rolling stock and of appliances, so that the Simplon railway was compelled to refuse some of the traffic it was asked to take over from the St. Gothard. The growth of the traffic on the St. Gothard Railway between 1885 and 1905, was in round figures, as follows :

	Number of				Receipts per kilometre (per mile).	
	passenger-kilometres	(passenger-miles).	ton-kilometres	(English ton-miles).		
1885	45,000,000	(27,960,000)	88,000,000	(53,820,000)	39,600 francs	(£2,549)
1890	63,000,000	(39,150,000)	105,000,000	(64,220,000)	49,600 —	(£3,193)
1895	77,000,000	(47,850,000)	127,000,000	(77,670,000)	61,700 —	(£3,972)
1900	139,000,000	(86,370,000)	139,000,000	(85,000,000)	73,000 —	(£4,700)
1905	166,000,000	(103,150,000)	178,000,000	(108,860,000)	88,400 —	(£5,690)

The number of passengers and of tons of goods conveyed were as follows :

	Passengers.	Goods.		
1895	1,624,000	825,000	tons.	
1900	2,636,000	978,000	—	(in the preceding year about 1 million tons).
1905	3,333,000	1,248,000	—	

The growth of the traffic has thus been practically continuous, although very slight set-backs have sometimes occurred, as for instance in 1900 in the goods traffic. The rate of increase showed much variation; generally speaking a greater increase of passenger was attended with a smaller increase of goods, and *vice versâ*.

Between 1885 and 1890, the passenger mileage increased 40 per cent, while the goods ton-mileage only increased 19 per cent; in the next five years, the former increased 22 per cent, the latter 29 per cent. During the next five years, 1895-1900, the goods traffic showed an increase of 9·5 per cent only, whereas the passenger traffic showed the remarkable increase of 80 per cent. Finally, during the next five years the goods traffic increased by 38 per cent, the passenger traffic increasing by much less. In the twenty years which we are considering, the receipts per kilometre increased from 39,600 francs to 88,400 francs (£2,549 to £5,690 per mile), an increase of 127 per cent; the expenses increased from 18,250 to 52,900 francs (£1,175 to £3,405 per mile) (increase, 190 per cent). The latter figure shows how great the expenditure and the wear of the rolling stock are, and that there are other expenses which operating an Alpine line entails. The number of locomotives nearly doubled between 1883 and 1905; the number of wagons was increased during the last few years from 1,323 to 1,752; the average weight of a passenger carriage increased during the same time from 12·1 to 17·2 tons (from 11·9 to 16·9 English tons).

An Alpine railway with so many curves, gradients and constructional works as the St. Gothard, can never be looked upon as finally completed, as there are continual changes in the land, shifting slopes, decaying rocks, rivers and torrents, avalanches and earth-slides. Consequently, as soon as the original works had been completed, it was recognized to be at once necessary to proceed to very important supplementary works and renewals, and as more experience was gained, more and more works were found to be advantageous. Retaining walls had to be put in on rock slopes, cuttings and unlined tunnel sections required continual attention, sloping ground had to be removed, retaining walls to prevent avalanches had to be built, and the sheds and tunnels made for protection against avalanches had to be lengthened; moreover, it was necessary to build dams across valleys, regulate watercourses and carry out other protective works the need for which it had been impossible to foresee. The first few years after the opening of the line were fully occupied; existing stations were enlarged, and new stations added, customs sheds and other buildings were erected; the track was strengthened by relaying it with heavy 12 metre (39 ft. 4 in.) rails, the signalling system was improved, and more powerful locomotives were acquired. The second track was laid on the Bellinzona-Giubiasco section in 1883, and in the main tunnel in 1884. The same year, the Bellinzona commune presented a large piece of land for the erection of the main St. Gothard workshops, and as the shops which had at the start been erected at Erstfeld and Chiasso had in the meantime become too small, the erection of the main workshops was begun in 1887 and completed in 1889, the total expenditure on them amounting to nearly 2 million francs (£80,000). In the same year, the company also moved into its new offices at Lucerne; their construction had also been begun in 1887. Much greater expense and trouble was involved in the duplication of the whole track (the tunnel excepted, which was already double-tracked) between Erstfeld and Biasca; this was made necessary by the development of the traffic and was begun in 1888. This alteration, which cost 12,500,000 francs (£500,000), was successfully carried out and completed without any accident by summer 1903. It was certainly a very difficult and costly piece of work to duplicate a line, of so difficult a character, without in the least disturbing or endangering the traffic, which then already comprised fifty trains per day. The single-track tunnel sections built on the Pressel-Kaufmann system, on the two lines of access, were enlarged gradually during intervals between trains; it was possible, except in rare cases, to leave them unlined. The total expenditure actually did not equal that which, taking the saving of interest into consideration, would have been incurred, had the whole line had two tracks from the beginning. Besides this chief mountain section, which it may be incidentally remarked is about 50 kilometres (31 miles) longer than the double-track sections of the Brenner and Mont Cenis railways, there were in 1893 still eighteen single-track tunnels, having a total length of about 9 kilometres (5·6 miles). The capital outlay on the St. Gothard Railway, when completed in 1883, amounted to 220 million francs (£8,800,000) in round figures; in 1893, after the mountain section had been duplicated, to 261 millions (£10,440,000); and in 1905, with all the subsequent additional outlay, to 291 million francs (£11,640,000). When the Confederation accordingly wishes to buy out the company, it will be a financial operation of considerable magnitude.

On June 1, 1897, exactly fifteen years after the St. Gothard Railway service first began to run, the system and its consequent importance, was materially augmented by the addition of four new lines of access. In the first place, the Lucerne-Küssnacht-Immensee line was at last opened; this had already figured in the original proposal, and its construction had only been put off so long for financial reasons. Apart from the fact that the journey is made nearly one third shorter, the line has become of much importance as regards tourist traffic, as it runs through very charming scenery. The three other lines of access, of direct or indirect importance to the St. Gothard, are the lines Zug-Waldwyl-Goldau, Zurich-Thalweil-Zug, Schaffhausen-Eglisan. They shorten the access to the St. Gothard from the north-east by from 18 to 28 kilometres (from 11 to 17 miles), and have become of considerable importance for the German-Italian traffic going through Stuttgart. The most important constructional works on these new lines are the Albis tunnel, 3,358 metres (1 mile 1,598 yards) long, and the great viaduct over the Rhine at Eglisan, where there are twenty stone arches 60 metres (197 feet) high. In the meantime, the duplication of the track was continued steadily, the section Immensee-Brunnen being the last, involving an outlay of about 3 million francs (£120,000). Thus in 1905, the St. Gothard Railway had 143 kilometres (89 miles) of double track (Immensee to Brunnen and Flüelen to Giubiasco). The duplication of the Giubiasco-Chiasso section, and more particularly of the difficult Brunnen-Flüelen section, has also been considered, and was already demanded by the Federal Council in 1905. But it is easy to understand that this proposal is not hailed with enthusiasm by the shareholders, who accuse the Council of wishing to accelerate that duplication, in order to take over the whole completed undertaking under favourable terms. The last phase in the technical development of the St. Gothard, is marked by the negociations undertaken by the company (¹) to acquire in good time sufficient water power in the Tessin canton, to enable it to adopt electric traction as soon as that question has become sufficiently well worked out.

There is still much uncertainty as to the conditions under which the State will buy out the company, which may be expected to occur in 1909. All the proposals so far made have been recognized to be inapplicable owing to the complicated position of affairs, which is made still more difficult by the relation of the St. Gothard Railway to the States who gave subventions. Switzerland, Germany and Italy, who each contributed large sums towards the construction of the railway, thereby acquired certain rights which are defined in the statutes; more especially is it specified that when dividends exceeding 7 per cent are paid to the shareholders, the States have a right to the surplus, and that when dividends exceed 8 per cent they can demand a reduction in the tariffs. The latter case has not yet arisen, but the former has several times; the last time in 1905, when 200,000 francs (£8,000) were paid over to the States concerned. It is true that the net profits of that year had reached 10,940,000 francs (£437,600), an exceptionally high figure; the previous five years had shown an average of 9,660,000 francs (£386,400), and no regular increase was any

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(¹) See *Zeitung des Vereins*, No. 84, 1906.

more to be observed. Any such increase is still less to be expected now that the Simplon tunnel has been opened; moreover, there is every reason to expect that the renewal of iron bridges and of other constructional works, which have a limited life and at present already absorb large sums, will after purchase by the State have to be carried out even more quickly. The last report also assumes that in the short period of independent existence which the St. Gothard Company will have, such high profits as those obtained in 1905 will not be seen again, and that that year has probably recorded the highwater mark of financial success of the railway. If moreover we consider the already existing and proposed Alpine railways on both sides of the St. Gothard line, which must necessarily take away some of its traffic, were it only temporarily, and on the other hand, the large expenditure which sooner or later the electrification of the line will involve, and also the fact mentioned above, that with growth of traffic the working expenses have increased half again as quickly as the gross receipts, it must readily be allowed that more than a decent return for the capital expended (subventions excluded) is not to be expected. All the more therefore, will Germany and Italy be ready to transfer their rights, on reasonable terms, to Switzerland.

The future development of the St. Gothard Railway depends evidently above all on the new Alpine railways, which have been built since the tunnel was opened, or are being built, or are being proposed. The Arlberg line, which was opened only two years after the St. Gothard, already had a certain influence, and the new eastern Alpine lines of Austria will do the same, in spite of their greater distance from the St. Gothard, as every addition to the traffic of another Mediterranean port (in this case Trieste) must react on the Genoa traffic which is, after all, the mainstay of the St. Gothard Railway. Possibly such a reaction may be but temporary, as there is a continual growth in the Transalpine passenger and goods traffic, and may soon be more than compensated; the continual increase in the number of competing lines however leads to the agreeable certainty that all the lines will be equipped as well as possible, both technically and economically, and offer all possible facilities to the traffic. It is well known that, up to the present, the Simplon traffic has been smaller than expected; but this is less surprising than that these high expectations were conceived before the construction of the lines of access from the north. No doubt the completion of the Lötschberg line will have a considerable effect; but on the other hand, any prospects of better communication from the west, from the French frontiers *viâ* Geneva and *viâ* Lausanne, seem of late to have become more and more unlikely. The French jealousy of the Lötschberg line has revived the old projects of a direct junction with Italy *viâ* the Mont Blanc or the Petit Saint Bernard; and improbable as it seems that it is likely that there will ever be enough traffic between the Mont Cenis and the Simplon for a third and very expensive Alpine railway, yet it is not impossible that French chauvinism may carry the day (¹). But to have to compete against three lines to the west, would be rather onerous for the St. Gothard Railway, even though the Swiss Federal Railways will later on be able to divide the traffic they have to deal with equally between the Simplon and the St. Gothard.

On the other hand to the east, the Splügen project, although it still has the also

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(¹) See *Zeitung des Vereins*, No. 8, 1907.

proposed Greina line as rival, begins to take a more definite shape, and one is hardly likely to be making a mistake in assuming that of these two projects the Splügen line, long desired by the eastern cantons, is the one most justified and has the better chance. As stated at the beginning of this article, the Luckmanier and the Simplon were the two Alpine lines which were already very much discussed before the St. Gothard was constructed, and really ultimately led to the decision to construct the St. Gothard tunnel. To-day, one of the two competing projects has been realized; instead of the other, the Splügen line will probably be built. Can there be a more conclusive proof that every new line of communication leads to better and better intercourse between nations and peoples, and greater and greater exchange of traffic, and that across the Alps which once were looked upon merely as a terrible barrier?

[656 .211 (.73)]

PASSENGER STATIONS AND TRAIN YARDS IN THE UNITED STATES,

By E. GIESE and Dr. BLUM,

MEMBERS OF THE BOARD OF WORKS.

Figs. 1 to 52, pp. 1113 to 1152.

(*Zeitschrift des Vereines deutscher Ingénieure.*)

INTRODUCTION.

The passenger stations in the United States do not seem to present any special features to the superficial observer, or even to the specialist who does not carefully examine the arrangement of the tracks. This impression, which also makes itself felt in several publications issued of late, is partly due to the fact that most of the United States stations, as far as their general arrangement and also as far as certain details are concerned, have not yet arrived at that pitch of development that is usual in our new designs. What is more especially lacking in America, are crossings with high roads and railways at different levels, approaches to platforms free from level crossings, and tracks arranged according to the direction in which the trains run.

When stations are now rebuilt in Germany, if several lines enter one station, then at least the crossing of cars running in opposite directions, at the same level, is avoided by bridging, so as to reduce the risks and attendant delays as much as possible; in many cases also, the goods tracks branch off from the main passenger tracks without having any crossings; much importance is also attached to having at least the entrance tracks clear and without obstacle right into the station, as this very much helps the safety and punctuality of the service. The great development of track systems with numerous skew bridges, which are at present to be found in our country near every important centre, are the result of these tendencies. As instances, we may mention the reconstructions at Dresden, Cologne and Hamburg, the construction of separate suburban tracks at Berlin, and at the centres of Altona and Charlottenburg. These arrangements become still more complicated in order to avoid the level crossing of roads; such are no longer made even in the country, outside cities.

In our larger stations moreover, at least one track and one side of a platform are used for each direction of the main line service, and we try to reserve such track for one definite use only, both in the interest of a safe and regular service, and in order to make it as easy as possible for passengers to find their way about. The attempts to make not only the train service but also all shunting operations as safe as possible, have resulted in Germany, during late years, in the construction of systems planned strictly in accordance with the direction of running; in these accordingly, the lines carrying trains running in the same direction are next to each other. In nearly all the more recent designs, the main lines are so arranged that no shunting operations take place on them; separate branches, sidings, loops and crossings, are provided for these purposes. Our platforms, as in most other countries in Europe or under European influence, are distinct and separate from the permanent way; this is more particularly effected by having tracks and platforms at different levels. Thus the superficies of a station is sharply divided into two parts, one for the trains, namely the tracks, and another for the passengers, officials, mails and luggage, namely the platforms. In a number of cases, the passenger platforms are used for passengers only, separate luggage platforms being provided for luggage and mails; the passengers can then move about freely and safely on their platforms. The safety of the passengers is still further increased by the provision of foot-bridges and subways, so that passengers can reach the platforms without having to cross the lines; it is true that such provision is not yet as complete in Germany as in England and its colonies, but it is more ample than in some other European countries.

The station improvements just enumerated certainly seem, in some cases, to be going a little too far; for there is a tendency for officials to feel less responsible and for passengers to become careless and casual; moreover, they are very costly and easily result in a certain stiffness in the whole system, which as the traffic is continually changing and growing, should be pliable and adaptable; for even small changes often require large installations to be destroyed.

The tendency towards further development of station design in these directions, is only shown in America in a few recent cases. But it would be rash to draw any conclusions as to American engineers from this fact alone. If we make any such comparison between America and Germany, we must take the whole state of popular feeling into consideration. The German has, from early times, always been accustomed to be under a certain amount of tutelage; he is quite ready to tolerate a certain amount of interference with his personal liberty, if done by authority; he by no means dislikes it if the State — in this case the railway administration — undertakes the responsibility of looking after the safety of each individual. America is however a " free country ", and the American does not like to be hampered by regulations; but then he undertakes to look after his own safety. We do not wish to be apologists for the risk which arises in America from the numerous crossings of railways at the same level across each other or across highways and from the defective arrangement of the stations, still frequently noticeable; but all the habits and tendencies of the nation must be taken into consideration, and the whole blame must not be laid on the engineers. It must certainly be admitted that they are not so well trained, as regards the management of traffic, as the German railway technicians; but this is due both to the nature of their training and their occupation. For on the Prussian railways, to the great advantage of the whole service, the traffic has always been managed by the technicians, and as the whole traffic originates from stations, our station arrangements, particularly as far as everything which facilitates traffic is concerned, are excellent, and have, in many respects, served as a pattern for the whols world. But in America, up to the present, the traffic has to a large extent been managed by officials of the business departments; consequently, the technicians were ill-informed and were not acquainted with the special traffic arrangements which were desirable, from the point of view of the traffic, at the stations. But now matters are fundamentally improved, as many of the American railway Companies have, for some considerable time, adopted the practice of appointing engineers to the chief positions in the traffic department and in the whole management generally.

I. — Entrance of railways into stations.

a) Crossings at rail-level.

As already mentioned, the arrangement of tracks near stations in America often has the disadvantage, that different tracks cross each other at the same level. Only in rare exceptional cases, do the goods tracks branch off from the main passenger tracks without any crossings; then also it is but rare that when several lines go into a station, bridges are put in to prevent passenger tracks from crossing each other. But not only do the tracks of one and the same railway cross each other at the same level, but in many cases also, the tracks of different railway companies. Thus for instance, in East St. Louis, twelve main lines coming from the east unite so that the passenger traffic may go over the Mississippi bridge, while for the goods traffic there are many local goods yards along the banks of the river, no bridges being provided for the many crossings which result. A particularly striking example is the entrance of the Pennsylvania into Buffalo, shown in figure I. Here there are a large number of tracks crossing each other at the same level, one double-track express line being crossed by many other express and goods tracks; moreover in places the two tracks are contracted into one. Similarly there is the entrance of the Illinois Central into Chicago, shown in figure 2; here the section which has from six to eight tracks used for main line suburban and goods traffic, is crossed at the same level by five express lines, with much traffic, belonging to other railway companies. In addition to this, there are also numerous crossings of the tracks belonging to the Illinois Central itself. Many such crossings are also still to be found on city railways, where they are particularly dangerous owing to the density of the traffic, thus for instance, at the triangles on the Boston Elevated, at the branch junctions on the New York and Chicago Elevateds, and at the entrance to the loops of the latter railway, although in the case of this remarkable city railway the interval between successive trains is sometimes less than a minute (¹); but plans have already been designed for eliminating the rail crossings.

(¹) This loop, a little over 2 miles long, covers the business centre of Chicago. Four main lines run into it; the two older ones, the Metropolitan and the Southside Elevated, use the inner track which has a better situation from the business point of view, whereas the other two use the outer track. There are nume-rous stations; but the whole loop may be considered as a joint terminus of the four lines. (*Vide* also the ***Bulletin of the Railway Congress***, No. 7, September, 1905, p. 2093.)

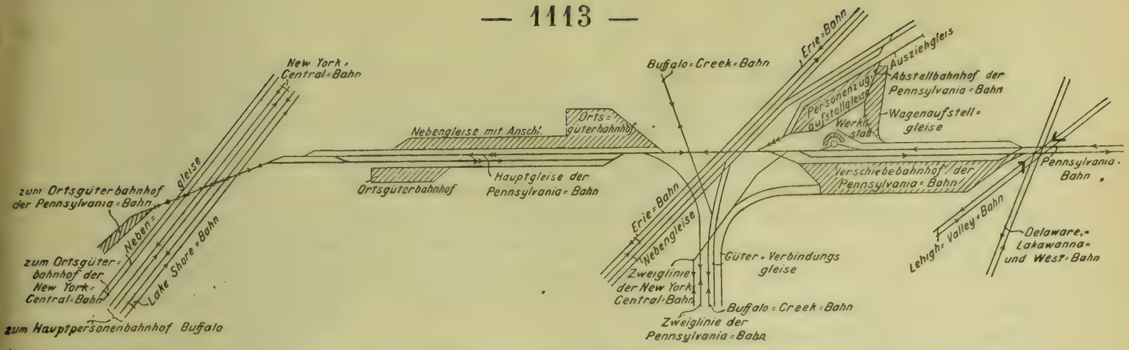

New York-Central-Bahn
Buffalo-Creek-Bahn
Erie-Bahn
Ausziehgleis
Personenzugaufstellgleise
Abstellbahnhof der Pennsylvania-Bahn
Wagenaufstellgleise
Werkstatt
Orts-güterbahnhof
Nebengleise mit Anschl.
Hauptgleise der Pennsylvania-Bahn
Ortsgüterbahnhof
Verschiebebahnhof der Pennsylvania-Bahn
Pennsylvania-Bahn
zum Ortsgüterbahnhof der Pennsylvania-Bahn
Nebengleise
zum Ortsgüterbahnhof der New York-Central-Bahn
Lake Shore-Bahn
zum Hauptpersonenbahnhof Buffalo
Erie-Bahn
Nebengleise
Zweiglinie der New York Central-Bahn
Güter-Verbindungsgleise
Buffalo-Creek-Bahn
Zweiglinie der Pennsylvania-Bahn
Lehigh-Valley-Bahn
Delaware-Lakawanna- und West-Bahn

Fig. 1. — Entrance of the Pennsylvania into Buffalo.

Explanation of German terms : Abstellbahnhof = Train yard. — Ausziehgleis = Draw-out siding. — Bahn = Railroad. — Güter-Verbindungsgleise = Goods junction line. — Mit Anschl. = With connection. — Nebengleise = Side tracks. — Personenzugaufstellgleise = Marshalling sidings for passenger trains. — Verschiebebahnhof der = Shunting yard of. — Wagenaufstellgleise = Marshalling sidings. — Zum Hauptpersonenbahnhof = To the chief passenger station. — Zum Ortsgüterbahnhof = To the local-goods station. — Zweiglinie = Branch line.

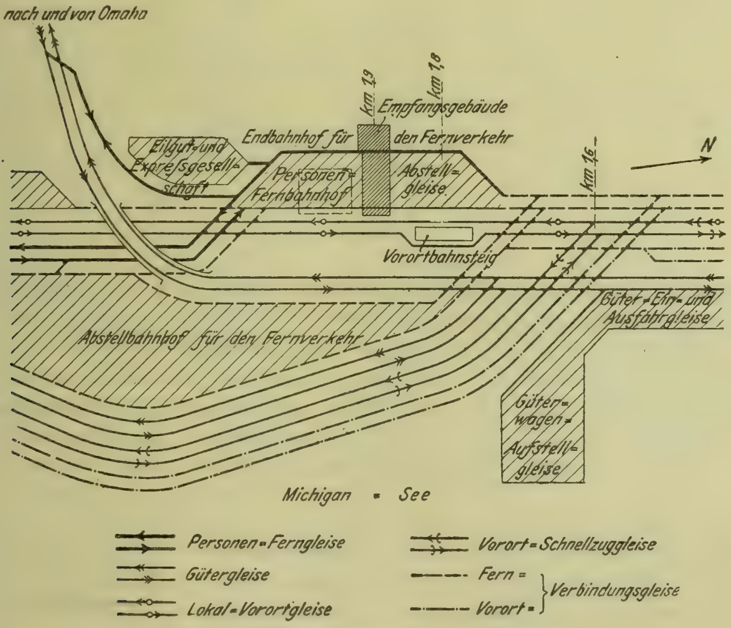


Fig. 2. — Illinois Central station, Chicago.

Explanation of German terms : Abstellbahnhof für den Fernverkehr = Train yard for main line trains. — Abstellgleise = Sidings for empty trains. — Eilgut- und Expressgesellschaft = Express company. — Empfangsgebäude = Passenger station. — Endbahnhof für den Fernverkehr = Terminus station for main line traffic. — Fern-Verbindungsgleise = Main line tracks. — Güter Ein- und Ausfahrgleise = Tracks for arriving and departing goods trains. — Gütergleise = Goods track. — Güterwagen-Aufstellgleise = Marshalling sidings for goods trains. — Lokal-Vorortgleise = Suburban lines, local traffic. — Michigan-See = Lake Michigan. — Personen Fernbahnhof = Station for main line passengers. — Personengleise = Main lines, passenger traffic. — Vorortbahnsteig = Platform for suburban passengers. — Vorort-Schnellzuggleise = Suburban lines, express traffic. — Vorort-Verbindungsgleise = Suburban line tracks.

In America also during the last few years, the conclusion has been arrived at that rail-crossings are not only a source of danger to the traffic, but also can delay it so much on busy sections that the efficiency of the whole system suffers. But only on the new city and suburban railways have crossings been systematically replaced by bridges. Thus for instance, the Boston Underground shows, as contrasted with the Elevated which is under the same management, no crossings of lines carrying traffic in opposite directions; and the sections now under construction or projected are also to be free from crossings. The same applies to the New York new Subway, and as far as at present settled, to the projected Philadelphia city railway, the construction of which has just been begun.

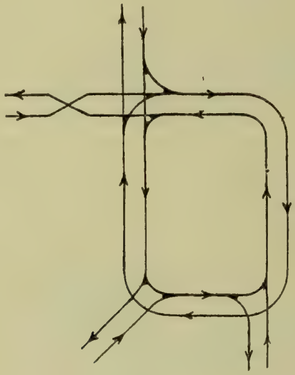


Fig. 3.

In the case of main lines, the present practice is still to a large extent limited to preventing the crossing of *different* railways by bridging. In many cases the level crossing of highways is at the same time eliminated by means of over or under-bridges. That however the new stations of important railway companies are not by any means yet perfect is shown in figure 4, which represents Englewood station, a suburban station south of Chicago. Here the highway it is true passes under the railway, but the very busy express and local lines cross each other at the same level.

To a large extent, rail crossings generally have been eliminated in the new arrangements made in connection with the electrification of the New York suburban traffic on the New York Central, and also in the alterations completed some years ago on the Pennsylvania west of Philadelphia. The railroad in question has there important lines running into this city, as shown in figure 5; namely from New York, Pittsburg and Washington. As the chief station is a terminus, there were delays and troubles in connection with the through traffic between the three stations named; and consequently, junction curves have been built outside which enable the through traffic on all three sections to be worked without running into the terminus. All rail crossings are avoided except one, where the Washington line branches off from its junction curve. The same is also as a rule true of the goods tracks, and in this connection, a goods elevated railway is specially worth noticing, as this

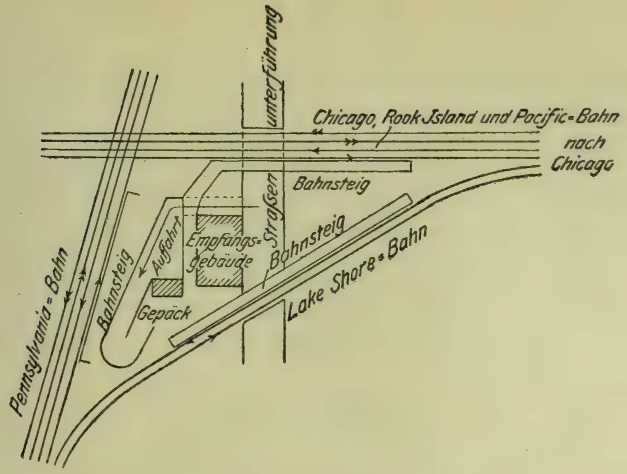


Fig. 4. — Englewood station, near Chicago.

Explanation of German terms : Auffahrt = Ramp. — Bahnsteig = Platform. — Empfangsgebäude = Passenger station. — Gepäck = Luggage. — Nach = To. — Strassen unterführung = Road crossing below.

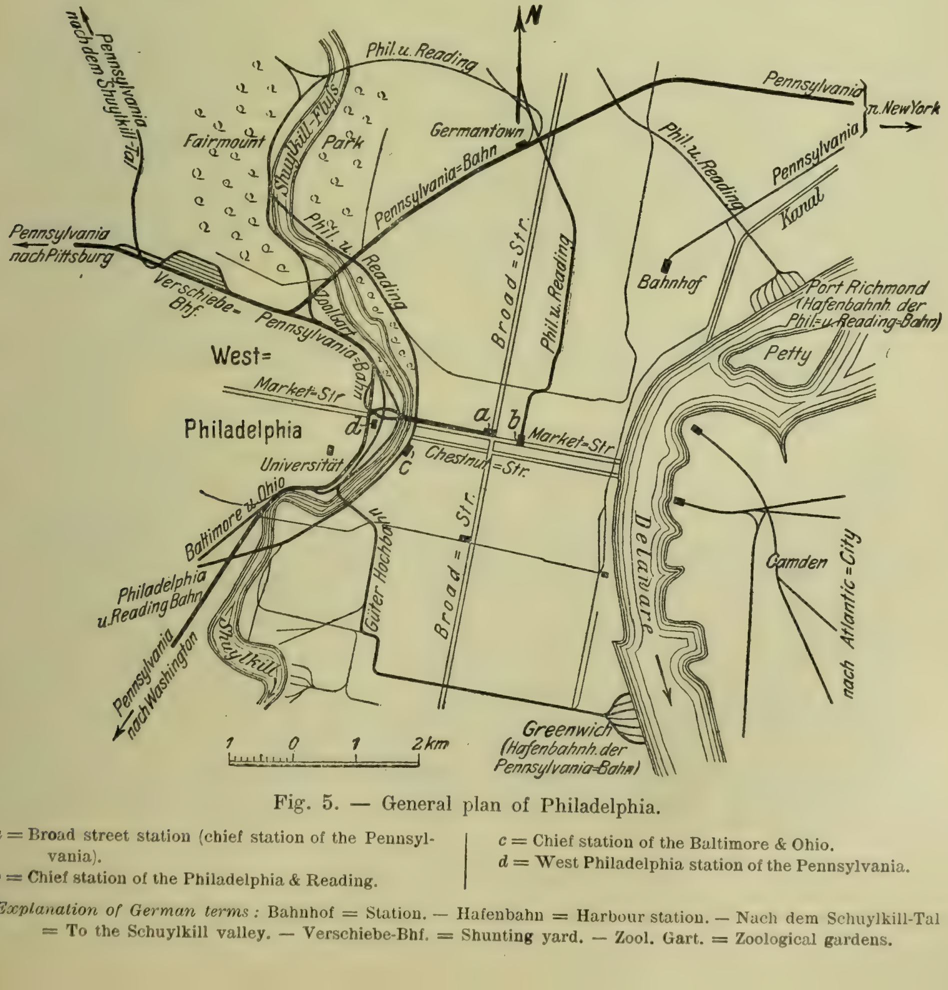


Fig. 5. — General plan of Philadelphia.

a = Broad street station (chief station of the Pennsylvania).
b = Chief station of the Philadelphia & Reading.
c = Chief station of the Baltimore & Ohio.
d = West Philadelphia station of the Pennsylvania.

Explanation of German terms : Bahnhof = Station. — Hafenbahn = Harbour station. — Nach dem Schuylkill-Tal = To the Schuylkill valley. — Verschiebe-Bhf. = Shunting yard. — Zool. Gart. = Zoological gardens.

costly arrangement makes it possible to deal with the through goods traffic without touching the passenger tracks. It should also be mentioned, that the through express trains running over the junction curves (for instance the New York-Pittsburg-Chicago-train), which accordingly do not run into the terminus, stop at other local stations, as it would not be advisable to run trains through Philadelphia, the third largest city in the United States, without stop there. The local stations so utilized are West Philadelphia for the trains to and from Washington, and Germantown for the trains to and from New York; it is true that Germantown is nearly 4 miles from the centre of Philadelphia. The arrangements of the Pennsylvania at Philadelphia, are probably the best yet made in America, as far as the proper arrangement of tracks in stations is concerned.

b) **Necks.**

Besides the many crossings, the traffic at the entrances of stations in America is also endangered and impeded by the fact that the separate tracks do not run independently through to the platforms, but are furthermore contracted before the entrance proper, so that bottle-necks are formed. Many American engineers do not as yet seem to attach much importance to independent through tracks, which are of great importance for the safety and efficiency of railways, and which we consider necessary, at any rate for all entrance tracks. In many cases even, interdependences and, consequently, points of danger, are put in where by very simple alterations, the tracks could be made independent. Thus to give a simple example goods tracks are branched off from the main passenger tracks very often as shown in figure 7, instead of as shown in figure 6; the result is that in an otherwise double-track goods section a short single-track section is inserted and thereby the simultaneous arrival and departure of goods trains is made impossible; moreover, this requires twice as many switches as the much more efficient and safe arrangement shown in figure 7.

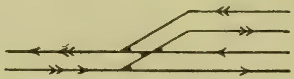


Fig. 6.

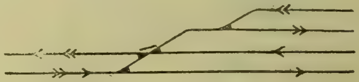


Fig. 7.

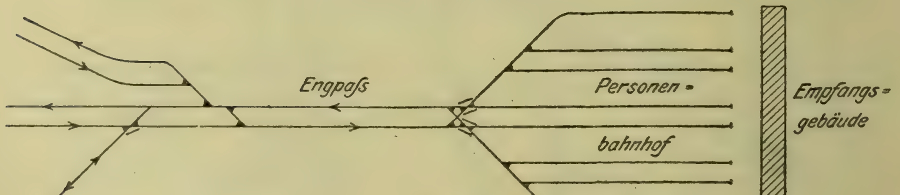


Fig. 8.

Explanation of German terms : Empfangsgebäude = Station building. — Engpass = Neck. Personenbahnhof = Passenger station.

If in America several lines run into one station, they seldom enter independently but already join up before. This seems especially remarkable when the joining up is very near the station; arrangements such as shown in figure 8, quite incomprehensible to us, are very common in America. The terminus of the Illinois Central at Chicago, for the suburban traffic, is shown in figure 9: here the two double-track lines to the station (main line and line to train yard) are certainly continued to the station, but the two tracks of each line are contracted to one track just before the point at which the platform sidings branch off, so that simultaneous arrival and departure on the same double track line is impossible. We should consider further provision necessary; at the very least that shown in figure 10.

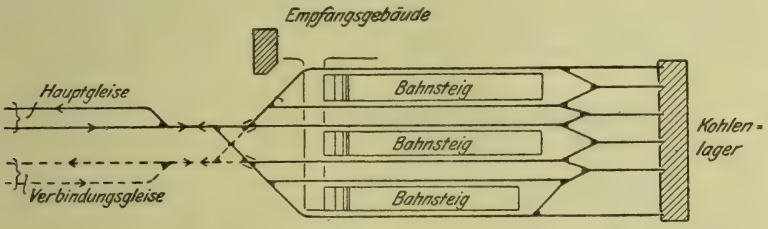


Fig. 9.

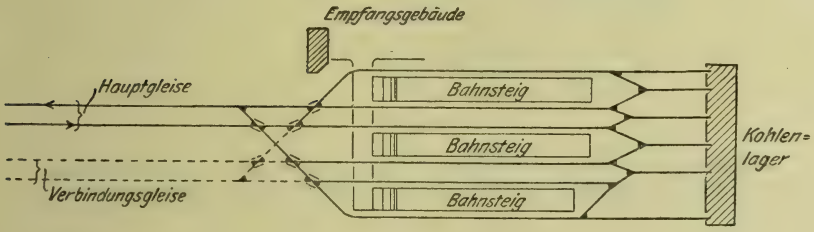


Fig. 10.

Explanation of German terms of figs. 9 and 10: Bahnsteig = Platform. — Empfangsgebäude = Station building. Hauptgleise = Main lines. — Kohlenlager = Coal store. — Verbindungsgleise = Junction lines.

Running into the chief railway station at New Orleans, is a double-track line, used by two railways; this, as shown in figure 11, is contracted to one single track just outside the station, before the goods tracks branch off; consequently, the movement of a single train blocks the whole station. According to German notions, additional track accommodation should be added to at least the extent shown in figure 12.

As a general rule, the presence of necks at the entrances of American stations leads to arrangements of the kind shown in figure 13, characterized by a large central diamond crossing. An increase in the number of through tracks is only to be found at very large stations, or if the main line has more than two tracks; but in this case also a simple central diamond crossing is retained, so that many arriving and departing trains would foul each other. Thus for instance, in figure 13, the simultaneous arrival and departure of trains on tracks *b* would not be possible. It is true that such narrow bottle-necks have the advantage that they are not costly, as less land and fewer switches are required, the switches require less gear for their operation,

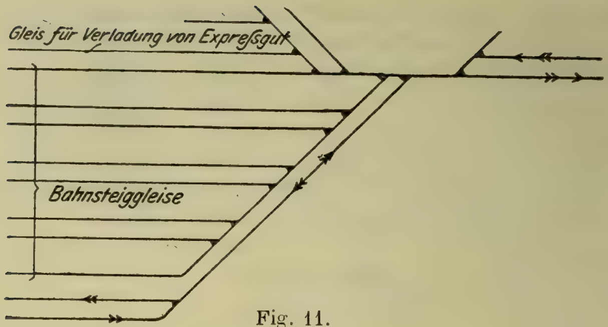


Fig. 11.

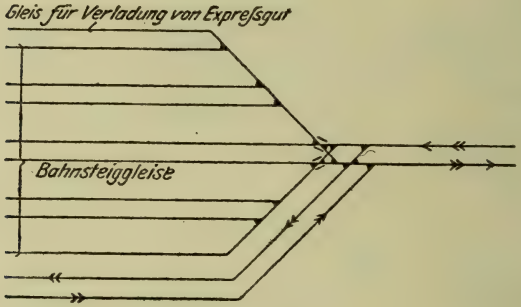


Fig. 12.

Explanation of German terms of Figs. 11 and 12 : Bahnsteiggleise = Platform tracks. Gleis für Verladung von Expressgut = Siding for loading express packages.

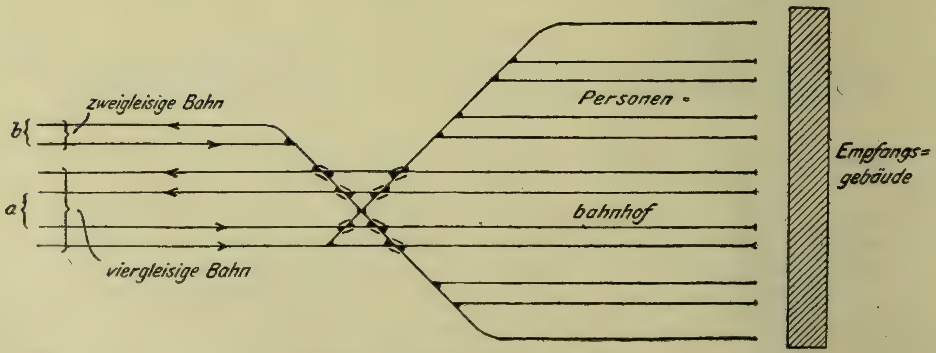


Fig. 13. — Neck before a station.

Explanation of German terms : Viergleisige Bahn = Four-track line. — Zweigleisige Bahn = Two-track line. Empfangsgebäude = Station building. — Personenbahnhof — Passenger station.

over-bridges and under-bridges for rivers and highways (if any) can be made narrower, and more especially it is easier to run the line in between houses. But this advantage of reduced capital outlay would in Germany hardly ever outweigh the inconvenience to the traffic. It must not be forgotten that the maintenance of such necks is very troublesome and costly, as owing to the density of the traffic there are hardly any intervals in which the more important renewals can be made, which however are naturally more often required on these sections which are subjected to much more wear and tear. Moreover, if a single car becomes derailed in such a neck, the whole station may be blocked, whereas in most of our arrangements the provision of an extra switch or two will generally make an alternate road available, as far as the more important routes are concerned, should one road be obstructed. Now as the chief switch tracks before the stations are, with few exceptions, only single, many arrivals and departures (see fig. 14) foul each other; but if the switch tracks were double, as shown in figure 15, simultaneous arrivals and departures would be possible.

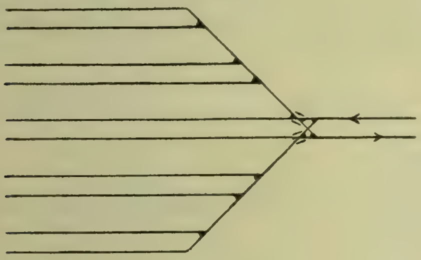


Fig. 14.

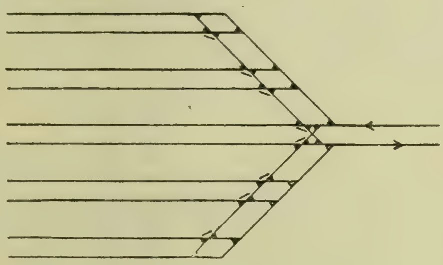


Fig. 15.

Now although we see that the Americans attach no particular value to the independence of tracks, yet on the other hand we note that they nearly always take care to arrange matters so that every platform can be used for arrivals from and departures in any direction. The presence of necks is in this way a great advantage, for as all the different tracks join up and form the one or two neck tracks, the different tracks and platform sidings can be joined up by means of the above mentioned system of a central diamond crossing, without any necessity for many switches or long switch tracks.

II. — Passenger stations.

a) Intermediate or road-side stations.

Intermediate stations are of less importance in America than terminus stations, firstly because the latter are plentiful, owing to the great number of different railway companies having lines to the more important centres, and secondly also, because the American railways do not devote much attention to the less remunerative traffic of small towns; and those stations, consequently, which are naturally road-side stations are less carefully considered than the terminus stations in the large cities.

The stopping places on single-track sections have, as a rule, a platform on one side; on double-track sections there is frequently also only one platform, at rail-level, which is sometimes supplied with a wooden flooring or gravelled. The other track has no special platform, and the only access is across the first track. The so-called " seven-foot " way, at such stations, is in many cases not made wider, and is often less than 4 metres (13 ft. 1 $^1/_2$ in.), so that passengers who are between the two tracks if trains come from both directions simultaneously, incur considerable risk. Such arrangements are even to be found on very busy sections of important railway companies, for instance, on the Boston suburban lines of the Boston and Albany Railroad. But as a rule, at very busy stations two outside platforms are provided, like at the English railway stations. Figure 16 illustrates an arrangement frequently occurring on the Pennsylvania; the two outside platforms being accessible from the highway which crosses the railway. On the newer stations of the Pennsylvania, where there is a busy local traffic, the highway crosses the railway at a different level, so that both platforms are accessible without any necessity for crossing the rails. As a rule, a railing is placed between the two tracks, to prevent the passengers from getting out on the wrong side of the train.

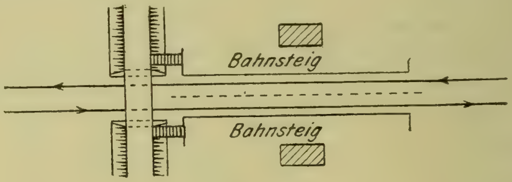


Fig. 16.

Explanation of German term : Bahnsteig = Platform.

On the stations of four-track sections, if operated according to direction, which is often the case, there are also two outside platforms, so that only the outer tracks are accessible; consequently, the trains which stop at intermediate stations must run on the outer tracks, and the inner tracks are principally used for through traffic (both passenger and goods). The design of these stations is, as a rule, very simple ; the station building often contains only a booking office and a small waiting room; in many cases each platform has its own independent building, as in England. There is seldom any special provision for dealing with mails, luggage and express packges. The suburban stations of the New York Central, now that the line is being electrified, will be altered so as to have platforms about 1 metre (3 ft. 3 $^3/_8$ in.) above rail-level, and bridges will be provided so as to make the platforms accessible without any need for walking across the tracks.

We saw but few island platforms, except in the case of city lines; but in this case also, outside platforms have, as a rule, the preference. Some of the Brooklyn and Boston Elevated stations have island platforms; then also there are island platforms at the double stations of four-track sections.

At intermediate stations, as a rule, when the number of main tracks is increased, the whole space between the rails is boarded over, so that there is no definite distinction between platform and track. As the arrangements of these stations have owing to the peculiarities described in the first chapter no special characteristics, it is only worth while to consider those stations which have special features. To this class, belong the stations which in design are intermediate stations, but are really chiefly used as terminus stations. Not unfrequently, there are cases in which the tracks, as shown in figure 17, Union Depot, Kansas, have platforms twice the length of a train. Opposite the centre of the station building, a level crossing, boarded or otherwise arranged, goes across all the tracks and from this crossing platforms extend in either direction. The intermediate station may in this way be considered to be split up into two terminus stations, where the tracks from opposite directions divide but meet again to form a continuous whole. The trains are then placed so that the central crossing remains clear; this cannot however always be carried out as naturally train movements and shunting operations across the middle are bound to occur. Denver station, which is similar, is shown in figure 18; this has the further peculiarity that it is also used for the narrow-gauge line going to Silver Plume, so that most of the tracks have three rails. A similar division into two halves used as terminus stations is to be found at Buffalo; but in this case, there is, in addition to the central level crossing, a foot-bridge giving access to the platforms; it is however used but seldom.

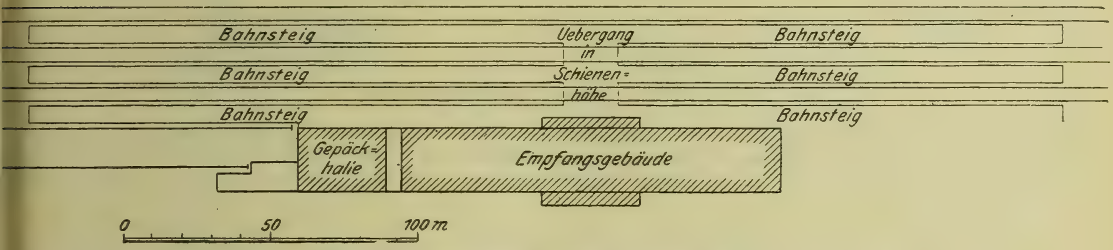
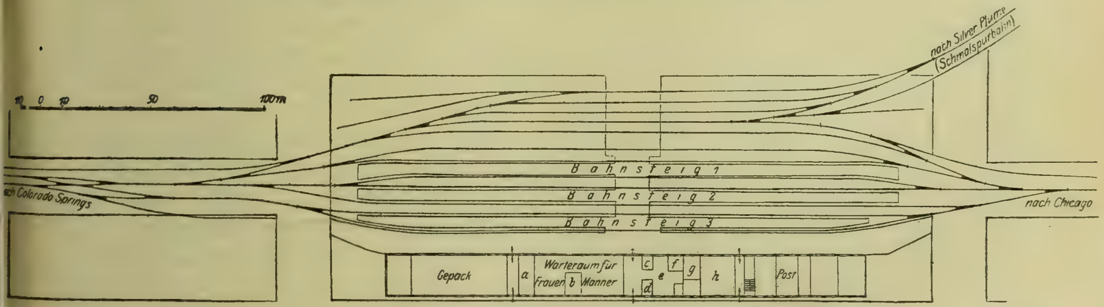


Fig. 17. — Central station, Kansas City.

Explanation of German terms : Bahnsteig = Platform. — Empfangsgebäude = Main building. — Gepäckhalle = Luggage hall. — Uebergang in Schienenhöhe = Level crossing.



. . . . . = Offices.
. . . . . = Booking office.
c . . . . . = Barber's shop.
d . . . . . = Lavatory.
e. . . . . . = Waiting room.
f. . . . . . = Paper shall.
g. . . . . . = Waiting room.
h. . . . . . = Offices.

Fig. 18. — Denver station.

Explanation of German terms : Nach = To. — Schmalspurbahn = Narrow-gauge railway. — Warteraum für Frauen = Waiting room for women. — Warteraum für Männer = Waiting room for men. — Bahnsteig = Platforms. — Post = Post office.

Where there is no rail-free access to the platforms, the arrangement just described must be considered a good one for through stations, as it combines the advantages which terminus stations offer passengers with those which through stations offer to the traffic. Similar arrangements also exist in Europe in countries in which rail-free access is not yet universally provided; for instance, at several large stations in Italy.

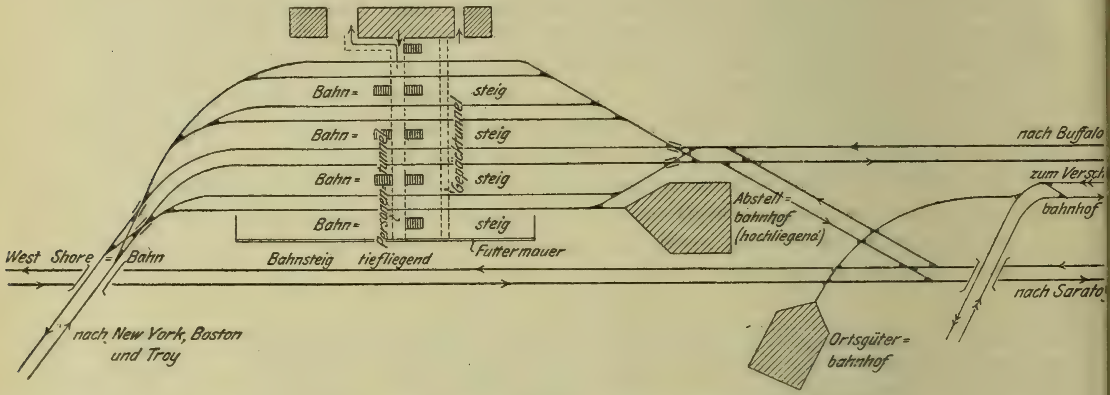


Fig. 19. — Albany passenger station.

Explanation of German terms : Abstellbahnhof (hochliegend) = Train yard (high level). — Bahnsteig tiefliegend. = Platform (level). — Und = And. — Futtermauer = Retaining wall. — Nach = To. — Ortsgüterbahnhof = Local-goods station. — Z Verschiebebahnhof = To shunting yard. — Personen tunnel = Subway for passengers. — Gepäck tunnel = Subway for lugga — Bahnsteig = Platform.

It is certainly much better to connect the platforms and booking-offices by subways or bridges, and so eliminate all level crossings. But this principle has only in a few cases been carried out in America. In the first place, we must mention Albany station on the New York Central; here there are the four through tracks between New-York and Buffalo (and on to Chicago), but also a number of branch lines, more particularly the important line to Boston. The station, shown in figure 19, consists of two parts; the part which is at a lower level is used by another railway company and is not worth special attention. The main part is new and at a higher level; it is built on what is known as the " German principle ", and resembles Hanover station. The booking office is at the same level as the street, and is well and substantially built; subways lead to the platforms and there are two tracks between each two platforms. All platform sidings join up at both ends into two main tracks; the branch lines only diverge further out, as shown in figure 20. The goods traffic of the New York Central does not run through the station; the pair of tracks used for the goods traffic is on the other side of the Hudson River and only joins the passenger tracks further on, north of the city. In connection with the passenger station, there is a small carriage depot, and near it also a small yard for local goods; the track going to this goods yard is not well arranged, as it crosses several main lines and streets at rail-level. The low-level part of the station is at the same level as the street and consequently as the subway; it has a very poor platform, hardly recognizable as such.

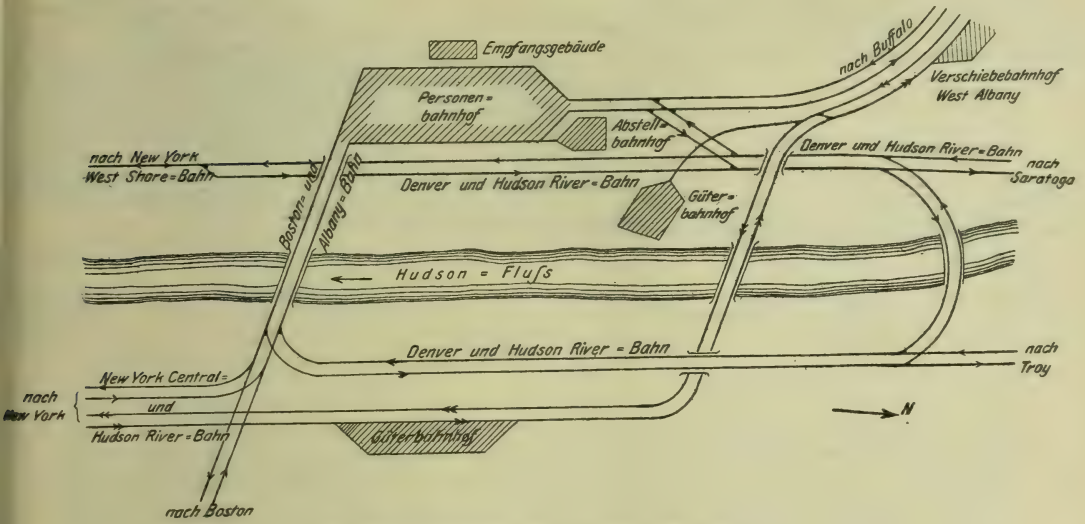


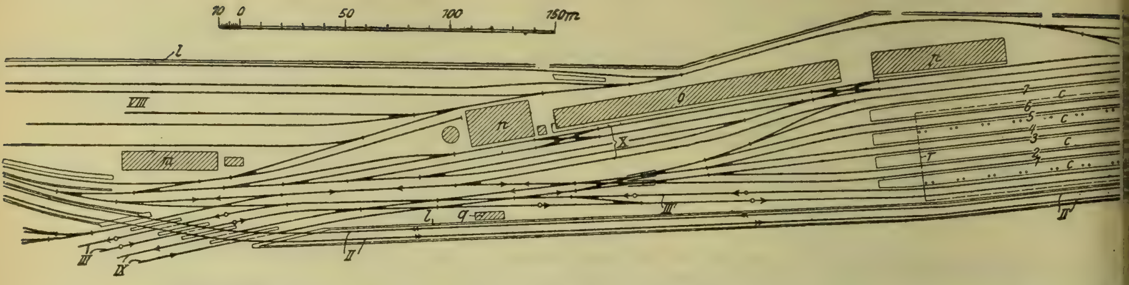
Fig. 20. — General plan of lines at Albany.

Explanation of German terms : Abstellbahnhof = Train yard. — Empfangsgebäude = Station building. — Fluss = River. Güterbahnhof = Goods station. — Nach = To. — Personenbahnhof = Passenger station. — Verschiebebahnhof = Shunting yard.

The terminus station of the Illinois Central at Chicago also deserves mention here; for although a terminus, it is arranged as an intermediate station. The platform sidings of the line, which comes from the south (see fig. 21) are continued to the north and there unite into two tracks outside, from which tracks branch off to the carriage depot for the long distance traffic and to the accommodation for the suburban traffic. Two sets of lines enter the station, from the south (New Orleans) and the west (Omaha), which unite, not very happily, to form a two-track neck just before where the platform sidings branch off; moreover, the access from Omaha has for a short distance only a single track, and the line to New Orleans is crossed at this place by the suburban pair of tracks at rail-level. The passenger station consists of seven tracks and four island platforms, which are at about the same level as the street. The station building is partly along one side of and partly over the rails; the passengers enter the booking hall, which is at the same level as the street and where tickets are issued and luggage is attended to, then go up to the waiting rooms, which are up above the tracks, and again descend by four sets of stairs to the platforms. The arrangement is thus not so good as at Albany, as there is more ascent and descent, but is worth mentioning as it is not necessary to cross the rails. The platform for the local traffic, also an island platform, is separate and access is obtained to it from the booking hall and the street by a tunnel.

The greatest intermediate station in the United States will probably be the chief station of the Pennsylvania in New York, now being built. Up till now, this rail-

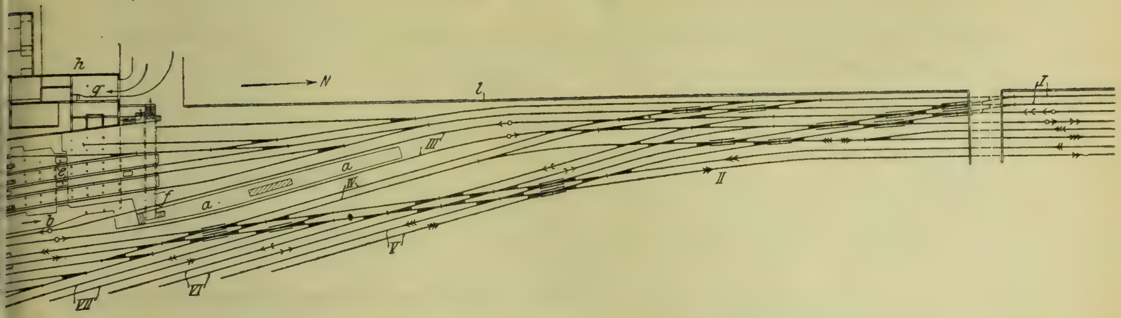
Fig. 21. — Illinois Central terminus station at Chicago.



a = Suburban traffic platform.
b = Passage to suburban platform.
c = Platform.
d = Train yard, main lines.
e = Crossings.
f = Subway.
g = Entrance.
h = Offices.
i = Luggage receiving office.
k = Staircase to waiting room.
l = Retaining wall.
m = Storage rooms.
n = Power station.
o = Shed for express packages.
p = Luggage
q = Signal
r = Station

way had no access to New York, but ended on the other bank of the Hudson, which here forms a wide estuary, in New Jersey; it was reached from the New York proper by ferries. As the traffic, particularly the local traffic, suffered considerably, a tunnel with four tracks is now being constructed under the Hudson to give the railway access to New York; it will pass under New York as an underground railway, and be extended through a tunnel under the East River to Brooklyn and Long Island (¹). A large station is being built in New York, consisting of two parts, one for the suburban traffic, the other and larger one for the long-distance traffic. The rail-level at the station, owing to the situation of the tunnel under the Hudson and of the city underground lines, is so deep down that the station can have four floors. The ground floor is level with the street; in it are the different entrances and numerous shops, which are going to be let. The floor below contains the chief waiting room and other offices, and the luggage offices. The luggage offices are directly connected with the platforms by lifts; in front of the chief waiting room is a long hall or corridor which extends across all the tracks and platforms, and is connected with the latter by lifts and staircases. But between this corridor and the platforms, there is another floor, which is connected with the platforms by separate staircases; this is to serve as way out, and stairs and lifts go direct from it to the street level. Consequently, arriving passengers do not pass through the booking offices, etc. The lowest floor, that is the third floor below the ground floor, has eleven platforms, all island platforms with tracks on both sides. The accommodation for the suburban traffic, for which two of the eleven platforms are going to be used, forms a separate part of the building and adjoins the other part. The whole design utilizes the great difference of height between street and rail-level not unskilfully, entrances and exists being kept separate; but the great difference of height which local conditions make unavoidable, will in spite of the many lifts, inconvenience passengers.

(¹) *Zeitschrift des Vereines deutscher Ingenieure*, 1906, p. 1124.



-out and junction tracks.
ks for goods to and from
aha.
l and suburban tracks.

IV = Junction tracks to main line train yard.
V = Junction tracks to suburban line train yard.

VI = Suburban express tracks.
VII = Chief goods tracks.
VIII = Loading docks.

IX = Main line tracks for passengers to and from New Orleans.
X = Sidings.
XI = Tracks for passenger to and from Omaha.

The intermediate stations which accommodate several lines, hardly differ in America from those which only accommodate one because as already stated the lines generally unite outside the station, so that the station arrangements generally start from one line; compare the plans shown in figures 18 to 21. For this reason it is unnecessary, particularly after the explanations given in chapter I, to consider junction and crossing stations of American railways any further, and we will therefore limit ourselves to giving a few examples, in order to show what antiquated arrangements still exist, and how the newer ones have been improved.

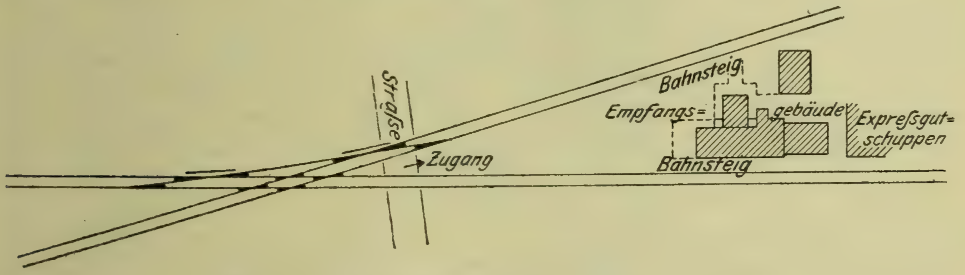


Fig. 22. — Wedge-shaped station at East St. Louis.

Explanation of German terms : Bahnsteig = Platform. — Empfangsgebäude = Station building. Expressgutschuppen = Express shed. — Strasse = Street. — Zugang = Way to station.

The East St. Louis station shown in figure 22 is on the east side of the Mississippi opposite the city and must not be confounded with the chief St. Louis station which will be considered later on. In this station, a number of the important lines from the east (Chicago, Pittsburg, New York) unite in order to cross that great river by one two-track bridge and then pass through a tunnel under the business part of the town to the chief station. The rail accommodation available is hardly sufficient for the traffic; all the more so as the direction of running of some of the trains is altered and locomotives are changed. The station-building is wedge-shaped, a very unusual form in America; it is true it is small, but as compared with the ordinary American stations it has quite a considerable extent. Access to it can only be obtained by crossing the rails.

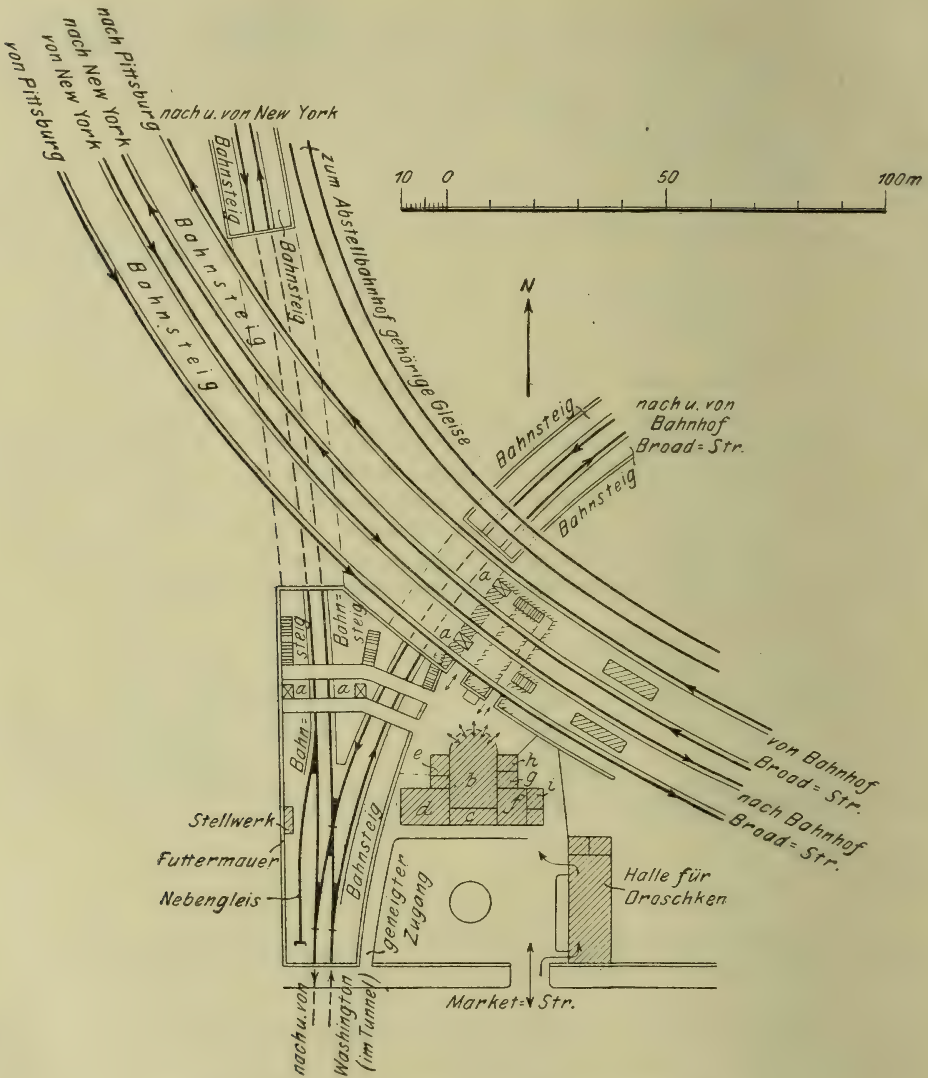


Fig. 23. — West Philadelphia station of the Pennsylvania.

a. . . . . = Lifts.
b. . . . . = Waiting room.
c. . . . . = Entrance hall.
d. . . . . = Luggage office.
e. . . . . = Booking office.
f. . . . . = Waiting room for ladies.
g. . . . = Hand-baggage.
h. . . . = Lavatory for men.
i. . . . = Lavatory for women

Explanation of German terms : Bahnhof = Station. — Bahnsteig = Platform. — Futtermauer = Retaining wall. — Geneigter Zugang = Inclined approach. — Halle für Droschken = Covered cabstand. — Im Tunnel = In a tunnel. — Nebengleis = Siding. — Stellwerk = Signal cabin. — Zum Abstellbahnhof gehörige Gleise = Tracks belonging to train yard. — Nach = To. — Von = From. — Nach u. von = To and from.

As compared with this East St. Louis station, Englewood station (rebuilt about six years ago, see fig. 4), to the south of Chicago, shows material progress as regards accessibility. The building is located in a fairly suitable position, and has two floors. The lower floor contains hardly anything except stores and service offices; the chief offices, rooms, etc., being on the upper floor, which is at rail-level. A road having a steep gradient gives access to the luggage and express sheds. Only one track of each of the three railways is directly accessible from the station; the other tracks can only be reached by crossing the rails, and no foot-bridges are provided.

In order to show that in America also there may be found stations, which satisfy all possible requirements in the way of safety and ease in dealing with traffic, we will conclude with intermediate stations by mentioning the West Philadelphia station of the Pennsylvania (see fig. 23). As already mentioned, and as the figure shows, this station receives the three lines from New York, Pittsburg and Washington, which continue from here to the important terminus, Broad Street station, which is further inside the city. The New York and Pittsburg lines unite already before the West Philadelphia station by a rail-free crossing to form a four-track section, operated according to direction of running. Below this, and at the station, the Washington line passes in a tunnel, which also passes under the train yard. From this Washington-Philadelphia main line, as previously mentioned, the curve for the through connection Washington-New York branches off; this is the only important point left, in the great reconstructions undertaken by the Pennsylvania near Philadelphia, in which trains going in opposite directions cross.

West Philadelphia station is thus a through station for the two lines to Washington and New York (and Pittsburg), and a junction station where the direct line to Washington branches off. The station building is not large, but well arranged and tastefully built of sound material. It is located in the angle formed by the two lines and is in height about halfway between the two rail-levels. The higher part forming the platforms of the four-track Philadelphia-New York (and Pittsburg) line is accessible from the entrance hall by two subways, for passengers and luggage respectively; there are two island platforms, one for each direction of running. These can thus be reached without walking across the rails. The lower part forming the platforms of the Washington line is connected with the entrance hall by two bridges, one for passengers and one for luggage; there are lifts and stairs to the platforms. In this case, the platforms are outside platforms, and separate for the two branches of the line; thus there are four platforms. There is also a direct way by which passengers and luggage can pass from the upper to the lower platforms and *vice versâ* without going through the station building.

b) **Terminus stations.**

In North America there are comparatively more terminus stations than in Germany; it may be said that, as a general rule, all large passenger stations are terminus stations. Most of them are terminus stations in the strict sense of the word, *i. e.* stations where all the trains start from and finish their journeys; the whole arrangement is therefore designed on this supposition. In the few terminus stations where there is through traffic, with trains which accordingly change their direction of running, no special provision is made for such traffic; up to the present, there is no systematic arrangement adopted in America for avoiding crossings, as may for instance be found at Altona; even devices for avoiding the necessity of entering a terminus station by having junction curves outside, are not to be found in America, except in the already described case of the Pennsylvania at West Philadelphia. Therefore all that is necessary is to describe the arrangements at the terminus stations, in so far as they are places where traffic starts and ends. Although the improvements made in the newer stations will also be considered, it may at once be stated that these consist not so much in a better arrangement of the tracks, as in a better design and arrangement of the station buildings, in their better location relatively to the streets and in their general arrangements; these sometimes go so far that the station quite loses its character as a terminus.

The sidings of the American terminus stations nearly all consist of a pair of tracks, with platforms in between, thus forming a series of bays. Access to these platforms is obtained from the end where there is a large cross-platform which forms the sole connection with the station building. All the offices are beyond the cross-platform; laterally placed buildings, as for instance the Postdam-Lehrte station at Berlin, are very rare in America, and this is by no means a disadvantage, as true termini, particularly if there are many tracks, are more convenient and easier to look after. The tracks under cover are free from switches and have dead ends; we did not see any turn-tables, traversers or cross-overs at such ends. Similarly, no sidings for locomotives to run back over, nor any sidings for empty trains between the platform sidings proper, are to be found in America; thus in these respects the American stations are arranged with the same proper simplicity and directness as our newer stations, in which the complications so much liked formerly are now eliminated. The end cross-platform is often very wide and then forms a hall called a concourse or lobby, which is separated by a railing, containing the entrance and exit gates, from the intermediate platforms; the whole platform system being thus divided into two parts, a larger one accessible to everyone and a smaller one to which passengers only are admitted.

As a simple instance of an older terminus of medium size we show, in figure 24, New Orleans station, which is used by both the Illinois Central and the Southern Pacific. These two railways join some miles before the terminus at a large shunting station and then continue a double-track line to the terminus. Just before this is reached, a line branches off for the goods traffic to the Harbour station. The terminus, which is thus reached through a neck, consists of a series of platforms between each of which there is a pair of tracks, thus forming a series of bays. Access is by a large end cross-platform. In addition to the passenger sidings, there is a special siding for luggage and express packages, with ramps and sheds. The booking offices and rooms for the passengers are all on the ground floor of the station building; consequently they are at the same level as the street and as the track. One noticeable feature in the general arrangement of the station is that there is a level crossing, of a street across the tracks and platforms, at the north end of the station; this level-crossing is still under the roof of the station. The street giving access to the station is also crossed at a level by the goods line.

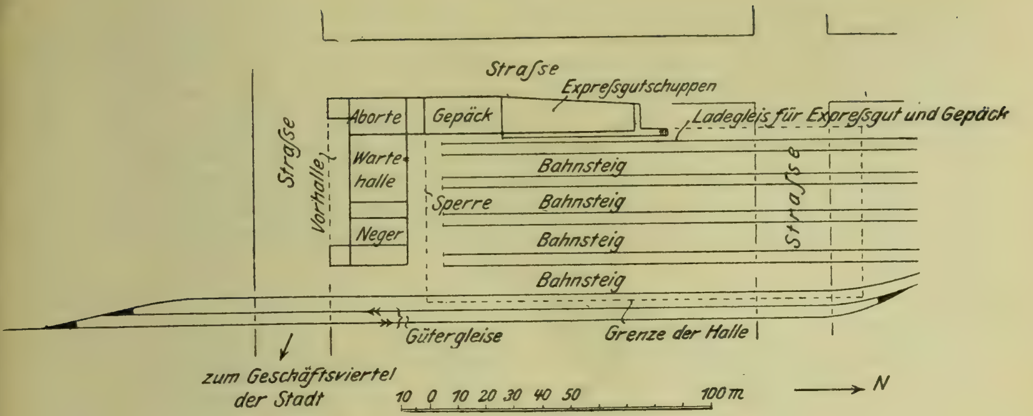


Fig. 24. — New Orleans station.

Explanation of German terms : Aborte = Lavatories. — Bahnsteig = Platform. — Expressgutschuppen = Express shed. — Gepäck = Luggage. — Grenze der Halle = Limits of hall. — Gütergleise = Goods tracks. — Ladegleis für Expressgut und Gepäck = Siding for express packages and luggage. — Neger = Negroes. — Sperre = Barrier. — Strasse = Street. — Vorhalle = Covered entrance. — Wartehalle = Waiting room. — Zum Geschäftsviertel der Stadt = To the business part of the town.

The arrangement of the tracks becomes a little more complicated, where the station is not a terminus only, but is also used for through traffic and consequently has tracks running through it. This is the case, for instance, with the Pittsburg station of the Pittsburg & Lake Erie (¹) (fig. 25). If we consider the arrangement of the majority of the tracks and their relation to a cross-platform and to the station building, we must call the station a terminus; but there is one pair of through tracks for passenger trains with the island platform I; this island platform is, however, only accessible by walking across one of the through tracks.

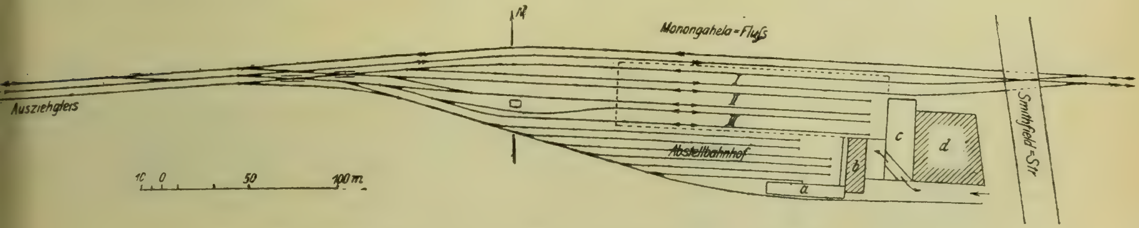


Fig. 25. — Pittsburg & Lake Erie passenger station at Pittsburg.

. . = Platform. | *a*. . . = Inclined approach. | *b*. . . = Express packages. | *c*. . . = Cross-platform. | *d*. . . = Station building.

Explanation of German terms : Abstellbahnhof = Train yard. — Ausziehgleis = Draw-out track. Monongahela-Fluss = River Monongahela.

This disadvantage is avoided, by an ingenious utilization of the land available, in the Baltimore station of the Baltimore & Ohio line (fig. 26). The chief part of the

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(¹) Vide *Zeitschrift des Vereines deutscher Ingenieure*, 1906, p. 1615.

station consists of a terminus station with its building at the end, with cross-platform and three intermediate platforms. In this case also, there is a through line (the Philadelphia-Washington main line) at the station. But this is not at the same level, but lower, as it runs through a tunnel under the city; the traffic through this tunnel is operated electrically. The double-track through line has an island platform, rail-free access being obtained by means of a bridge. A noteworthy point is that a separate platform is provided for the luggage in the one direction. Just as at New Orleans, the tracks, except the two low-level ones, are crossed at rail-level by a street.

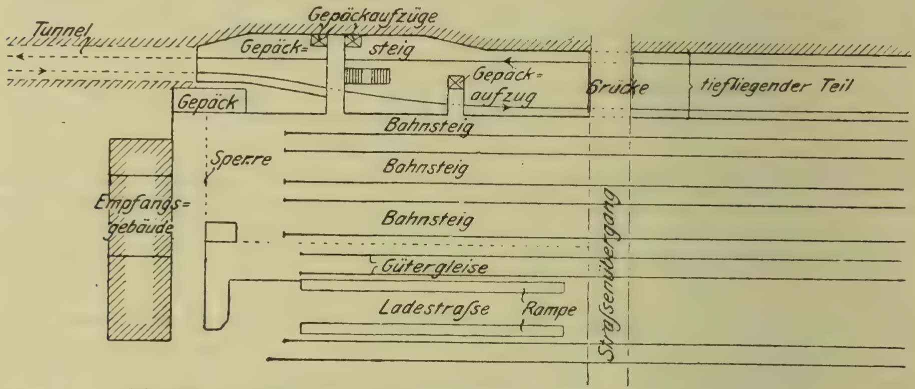


Fig. 26. — Baltimore & Ohio station at Camden Street, Baltimore.

Explanation of German terms : Bahnsteig = Platform. — Brücke = Bridge. — Empfangs-gebäude = Station building. — Gepäckaufzüge = Luggage lifts. — Gepäcksteig = Luggage platform. — Gütergleise = Goods sidings. — Ladestrasse = Road for loading up. — Rampe = Inclined approach. — Sperre = Barrier. — Strassenübergang = Street level crossing. — Tiefliegender Teil = Low-level part.

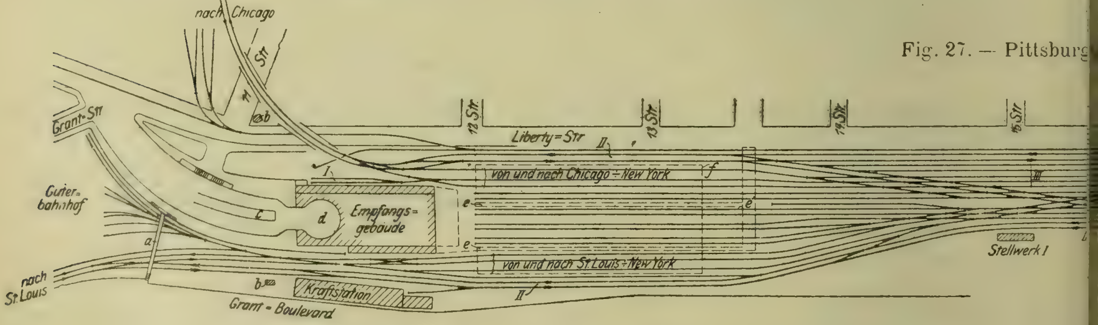


Fig. 27. — Pittsburg

a. . . . . = Foot-bridge.
b. . . . . = Signal cabin.
c. . . . . = Incline leading to lower floor.

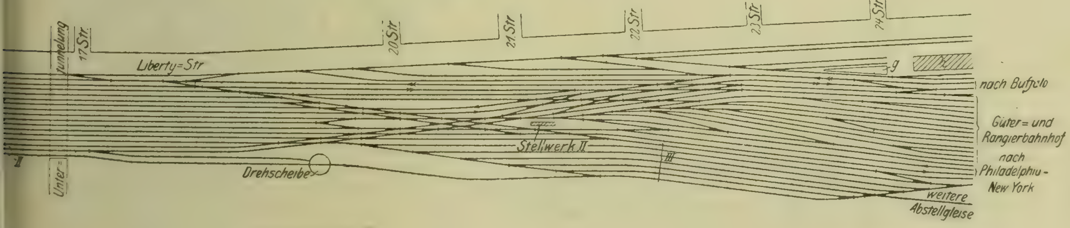
d. . . . . = Cab stand.
e. . . . . = Subway for luggage.
f. . . . . = Limits of hall over

Explanation of German terms : Drehsheibe = Turn-table. — Empfangsgebäude = Station building. — Güterbahnhof = Good
Untertunnelung = Subway — Von und nach

We may also here mention as an instance of a combined terminus and through station the chief Pittsburg station of the Pennsylvania, which probably is the largest such combined station in North America, and is one of the most important junctions of the great transcontinental lines (fig. 27). The station receives, from the east, the Buffalo line and the mostly four-track main line from New York *viâ* Philadelphia and Altoona. Two lines go west, namely to Chicago and St. Louis. The station can thus be described as the junction point of two main lines going through, and firstly as the junction station at which the New York line divides into two lines going to Chicago and St. Louis respectively. But as most of the trains from the east, especially the many local trains from the industrial district of Pennsylvania, do not go beyond the station, the greater part of this is arranged as a terminus station which contains eight dead-ended sidings and five intermediate platforms, with cross-platform. Beyond the latter is the station building, having its chief offices at rail-level; a lower floor is utilized for luggage, express and mail traffic. On both sides of the station building are the two lines to Chicago and St. Louis, so that it is really a wedge-shaped station. Owing to the level of the station offices and of the tracks, of each of the three through tracks to Chicago and St. Louis there is only rail-free access to the two inner ones.

As the through goods traffic at Pittsburg is also very important, on each of the two sides of the station a pair of goods tracks branches off, connected with the main passenger tracks to Chicago, St. Louis, Buffalo and New York by a series of switches and crossings. The system of switches at I is so arranged that all passenger and goods are connected in such a way that passenger and goods trains can pass from any one track to any other track, and that in addition, all platform sidings are accessible from all the main tracks coming from the east. A second set of switches at II, for the junction of the Buffalo and Philadelphia branches, makes the same train movements possible, so that there is a very great freedom of movement and the siding can be utilized to best advantage; it is true, however, that there are many crossings. Beyond the latter series of switches is the goods station and shunting

Pennsylvania Railroad.



. . . . = Ramp.
. . . . = Goods shed.
. . . . = Loco siding.
II . . . . = Main lines for goods.
III . . . . = Yard for passenger trains.
IV . . . . = Main lines for passengers.

l Rangierbahnhof = Goods station and shunting yard. — Kraftstation = Power station. — Nach = To. — Stellwerk = Signal cabin.
Weitere Abstellgleise = Additional train sidings.

yard, which is located between the passenger main lines to Buffalo and Philadelphia. The arrangements for the goods traffic (goods sheds and loading up sidings) are in part outside the two passenger lines, so that these have to be crossed by traversers. A speciality worth mentioning is a small goods station located near the passenger station; this is used chiefly for milk traffic and parcels and is consequently well in the city.

The train yard is outside and next to the main line to Philadelphia; it has a series of marshalling sidings, one behind the other, presenting no special features. The space available between the passenger station and set of switches II is utilized for a large number of lie-byes, which are joined up conveniently at both ends.

The terminus stations so far considered, with the sole exception of one low-level platform at Baltimore, have all their platforms, station buildings and the street entrance at one and the same level; we will now consider cases where track and street entrance are at a different level, and where consequently special provision has to be made for connecting the street entrance and the platforms.

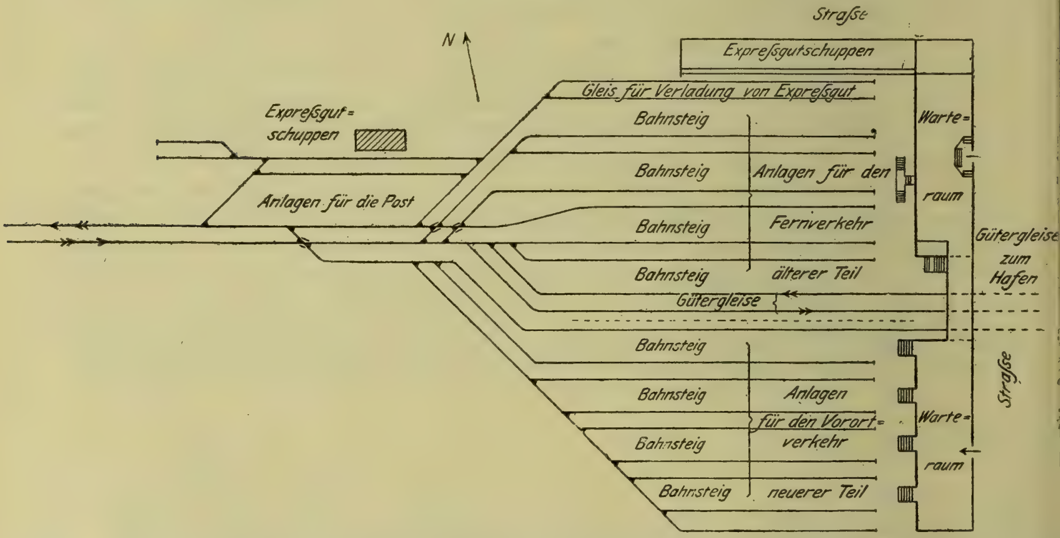


Fig. 28. — Chicago & Northwestern passenger station at Chicago.

Explanation of German terms : Aelterer Teil = Older part. — Anlagen für den Fernverkehr = Main line service. — Anlagen für den Vorortverkehr = Suburban service. — Anlagen für die Post = Mail service. — Bahnsteig = Platform. — Expressgutschuppen = Express shed. — Gleis für Verladung von Expressgut = Siding for loading express packages. — Gütergleise zum Hafen = Goods tracks to harbour. — Neuerer Teil = Newer part. — Strasse = Street. — Warteraum = Waiting room.

We will here first mention the terminus station of the Chicago and North Western in Chicago, part of which is fairly old and which has a very simple arrangement of tracks. This low-level station (see fig. 28) consists of two parts, the older north part being used for the main line traffic, wheréas the newer south part is during all busy times for the suburban traffic. Both parts are separated by the goods tracks which pass below the street and go to the harbour. The station building of the northern part has two floors. The upper floor which is a little higher than street level has a large waiting room, together with other accommodation, which is however but little used owing to the unfavourable position of the stairs. The booking offices are crowded into the lower floor, which is at rail-level; this floor is also directly accessible from the street to the north which has a steep downhill gradient. Next to this, as in the New Orleans station, are located the sheds for express packages, etc., together with the requisite siding; these form a wing of the main building. The newer part consists of a large waiting room and booking office, at street-level, with staircases leading down to each of the four platforms; this clear and simple arrangement is much superior to that adopted in the old part.

All the different sidings join up into a double-track line. Side tracks are practically absent; more especially are there no passing places, so that all the shunting operations involved in marshalling trains and taking them into or out of the station, affect the two main tracks, which are, moreover, crossed by a street at rail-level. A feature worth mentioning is the special siding provided for mails.

In this station, the existing difference of level is not yet sufficiently systematically utilized for the long-distance traffic. This has been done to some extent as regards the suburban traffic. But the arrangements for suburban traffic are so simple that no particular skill is required in utilizing the difference of level.

The Broad Street station in Philadelphia, now in use for more than ten years, however shows that Americans are capable of designing very ingenious two-floor buildings to suit complicated through traffic. This station is rather far inside the city, which the line enters at a high level, going over the streets; it is chiefly carried on stone arches. These, as well as the space under the platforms and sidings, are utilized for luggage and express packages. The station building is a sky-scraper with many floors, only the two lower ones being used for public traffic; the floor which is at street-level contains the booking and other offices, the next one, which is at rail-level, containing the waiting and refreshment rooms and giving access to the large cross-platform.

As shown in figure 29, two double-track lines enter the station from New York (and Pittsburg) and Washington, and a three-track line goes to the train yard. The sidings begin to branch off already far from the station at the set of switches near the Schuykill river; from here there are nine tracks. Of these, the most southerly one (track IX) is only for the short sidings of the many express companies, not shown in the figure. To them is let the whole space between Market Street and Commerce Street and utilized as two-floor goods sheds, the upper floor containing the sidings and loading and unloading arrangements, and the lower the offices and store rooms. Commerce Street, which is a side street of some importance, is crossed by a bridge carrying the connections giving access to these sidings. The eight other tracks can all be used, between the sets of switches I and II, completely protected by signals, in both directions; but the rule is that they are only used in the direction specified. The four middle tracks (tracks III to VI) are chiefly used for the temporary accommodation of empty trains and locomotives, as owing to the limited amount of space there are no other sidings in the immediate neighbourhood of the platforms. The eight tracks branch out at switches II (the chief signal tower), by a double system of switches and crossings, to sixteen sidings running along platforms; a pair being between each two platforms. The span of the roof is 93 metres (305 feet).

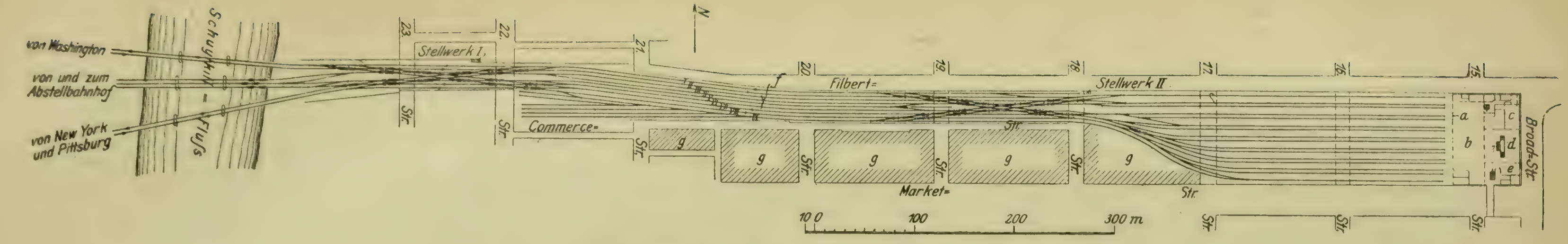


Fig. 29. — Broad street station, Philadelphia.

a = Barrier. | b = End platform. | c = Refreshment room. | d = Waiting room. | e = Ladies. | f = Sidings for empty trains.
g = Let to express companies; on upper floor, numerous sidings branched off track *IX*; below, offices and storage rooms.

Explanation of German terms : Schuylkill-Fluss = River Schuylkill. — Stellwerk = Signal cabin. — Von und zum Abstellbahnhof = To and from train yard. — Von = To. — Und = And.

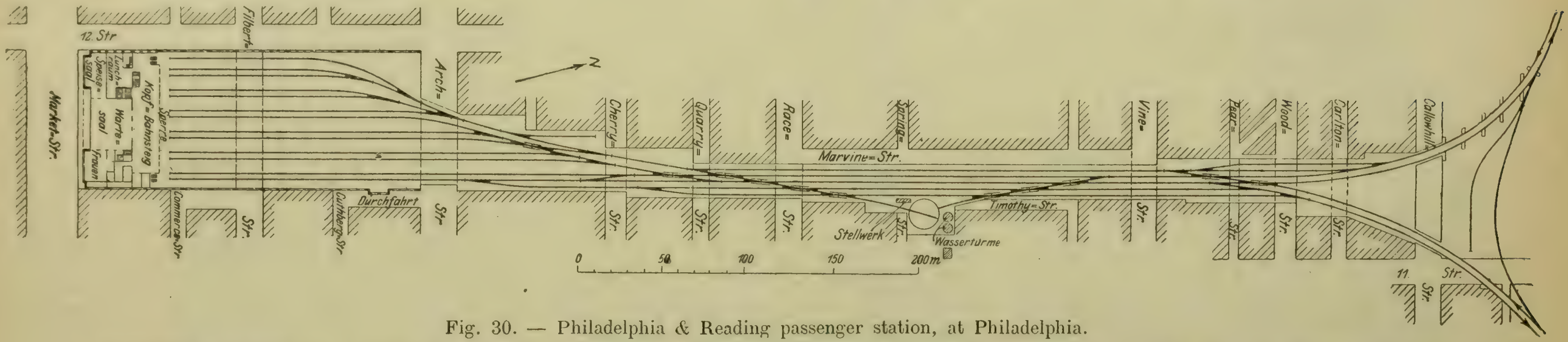


Fig. 30. — Philadelphia & Reading passenger station, at Philadelphia.

Explanation of German terms : Durchfahrt = Passage. — Frauen = Ladies. — Kopf-Bahnsteig = End platform. — Lunchraum = Lunch room. — Speisesaal = Dining room.
Stellwerk = Signal cabin. — Wartesaal = Waiting room. — Wassertürme = Water towers. — Sperre = Barrier.

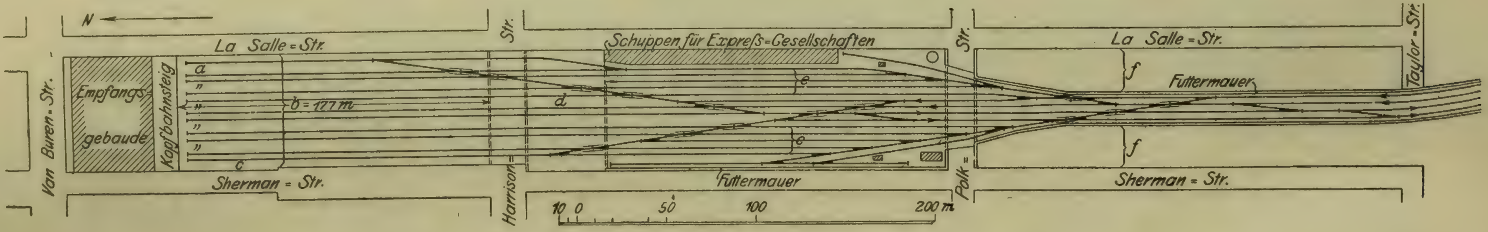


Fig. 31. — Rock Island passenger station, at La Salle street, Chicago.

a = Platform. | b = Hall covering platforms. | c = Platform for mails. | d = Power station below. | e = Marshalling sidings. | f = Goods station (low level).

The Philadelphia station (fig. 30) of the Philadelphia & Reading resembles the station just described and was built at about the same time; but it is not quite so large. From the north, two double-track lines enter, which pass through the city partly in a tunnel and then unite to form one four-track line. The latter branches out into thirteen sidings with intermediate platforms and one end platform. As at Broad Street station, there are no other sidings or lie-byes; although under the station building and under the roofed-over platforms, there are large store rooms for articles of food, so that the station accommodates not only a vast passenger traffic but also a fairly considerable goods traffic. The short siding running to the turntable, near which there is a water-tower and a coal supply, is used for turning the locomotives, which after a short stay there, are again used for hauling a departing train, without first going to any other depot. Such an arrangement which enables locomotives to run out again soon after arrival, is to be found fairly often at American terminus stations, the train yards of which and loco sheds are a long way off; it is an eminently rational plan from the economical point of view (compare the arrangements for the locomotive service at the Wansee and Südring station at the Potsdamer Platz in Berlin).

The La Salle Street station in Chicago (fig. 31) of the Rock Island Railroad, accommodates a four-track line operated according to direction. It is somewhat cramped, up to where the platform sidings branch out, by goods accommodation on both sides; but it is superior to the two previously described stations, in so far as a number of marshalling sidings, connected at both ends, are near the platforms. It is true that the provision of special sidings for empties, has been made impossible by the goods sheds on both sides of the line, which are at a lower level and cramp the passenger traffic, so that when shunting or marshalling operations have to be carried out, the main tracks have first to be used. Of the eleven platform sidings, the one located most west has an outside platform, chiefly used for luggage, express packages and mails. The sheds for the express companies, are similar to those at Broad Street station, Philadelphia, but are considerably smaller, consisting of one single long building extending along one goods siding placed next to the marshalling sidings. The station building is very well designed, particularly as regards the connection of the lower entrance hall with the end cross-platform.

The Pittsburg station of the Wabash Railroad, built recently, has a two-floor, and in a sense, an even three-floor arrangement. The railway, which runs in between blocks of buildings, had to be kept as narrow as possible, so as to avoid large expenditure on land; there are consequently only six tracks and three intermediate platforms, so that this station is much smaller than those previously described. On the other hand, the ingenious utilization of the irregularly shaped space which was available for the station and the system of dealing with luggage, both deserve attention. If the luggage van stops near the end cross-platform, the luggage is lifted direct to the level of the entrance hall; but if it stops near the other end, it is raised to the intermediate floor only, then run to the other end and then lifted there.

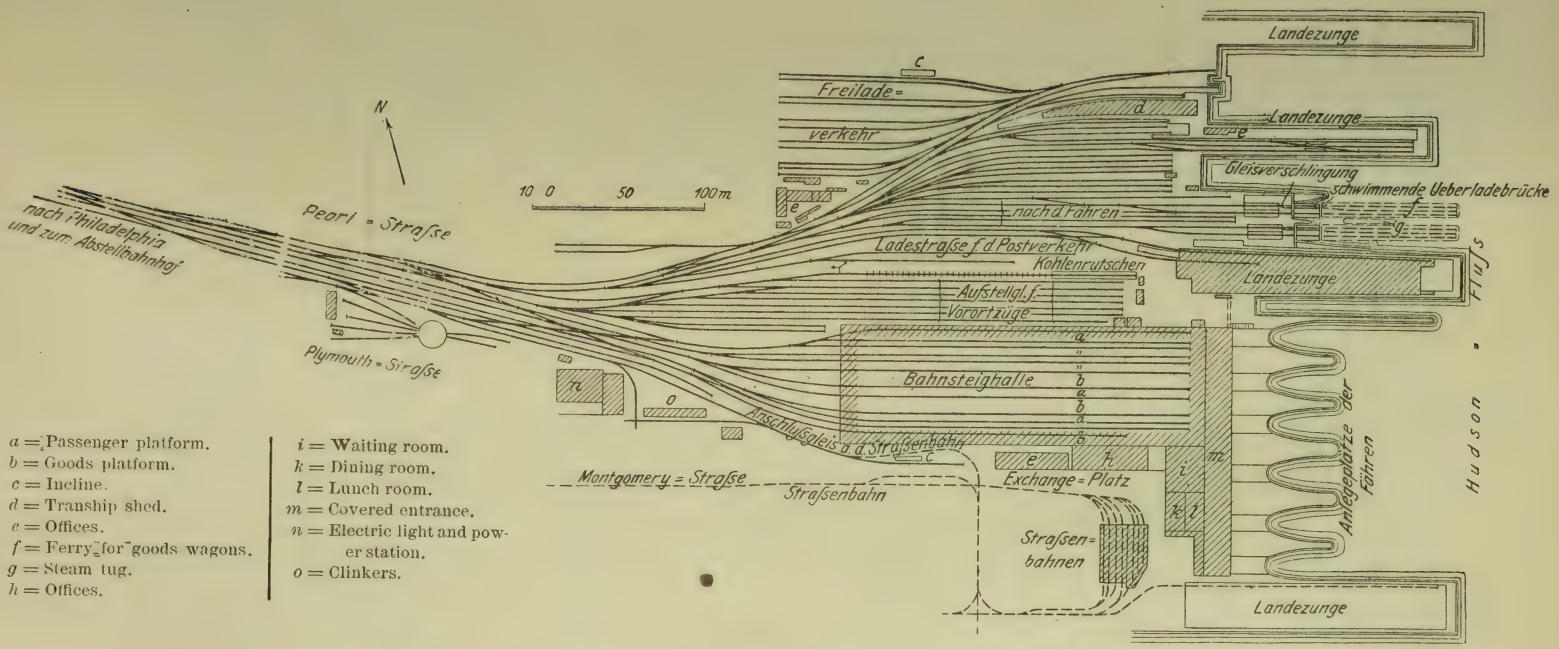
These four new terminus stations may be considered, as on a whole, equally well designed as our newer stations, although differences exist in the arrangement of the station buildings, which to a certain extent, is not quite so good as with us; but the difference arises from the national habits.

Among the two-floor stations, we must also include those terminus stations at which there are ferries. There are in America several important terminus stations, serving large cities but separated from them by wide rivers or estuaries, access to the cities being obtained by means of ferries only; such are to be found at New York, Philadelphia and Oakland (San Francisco). The ferries are broad heavy vessels which run equally in both directions, in order to save, as much time as possible, and to obviate turning. As a rule they are two-deckers, the lower deck being generally used for vehicles only and the upper deck being for the use of passengers. The terminus stations, to which these ferry-boats go, have a number of wooden piers going out at right angles to the shore, so that a number of boats can be accommodated simultaneously. One of the most important stations of this kind, is the terminus of the Pennsylvania Railroad in New Jersey (fig. 32), opposite New York; this will, however, lose much of its importance, when the above-described line Jersey-New York-Brooklyn and the new chief station at New York are built. The station has two floors, the tracks being on the upper floor. In the lower floor, which is at the same level as the street and the lower deck of the ferry-boats, provision is made for dealing with luggage and express packages; then also there is an entrance from New Jersey city. The whole New York passenger traffic is accordingly on the upper floor; the tracks and the upper deck of the ferry-boats being at the same level. The most important part of the whole building is a large hall, through which the traffic between the ferry-boats and the intermediate platforms passes; it can thus be considered as an end cross-platform, although owing to the space required for the piers and landing stages, it is considerably larger than would be required for ordinary intermediate platforms and sidings only. The different offices may be described, taking the large amount of traffic into consideration, as modest in their dimensions; however, the greater number of passengers are dealt with at the New York landing stage, where there is a corresponding amount of accommodation, particularly in the way of booking offices and luggage offices. A four-track line ends in the station; this has also to accommodate the traffic to the train yard which is some way outside; it is generally speaking operated according to direction. We have, however, noticed that here also trains were going fairly often on the left-hand side. It is worth mentioning as regards the way this four-track line is operated, that the trains arriving in the passenger station, are hauled by a shunting locomotive to the train yard; the locomotive following immediately behind the train for this distance of about 3 miles, not a block-section further back.

Next to the station hall, there is a group of five dead-ended sidings, chiefly used for suburban trains; then there are two sidings for the mail service and much provision for goods traffic, including a number of flying bridges for running goods cars on to ferries.

On the other side of the passenger station, there is (like at the Philadelphia station of the Philadelphia & Reading Railroad) a small siding with turn-table for the locomotives, and another branch going to the electric light and power generating station and connected with the tramway.

It has been recognized in America also that terminus stations have certain disadvantages inherent to them, which cannot be, avoided however perfectly every detail is worked out.



a = Passenger platform.
b = Goods platform.
c = Incline.
d = Tranship shed.
e = Offices.
f = Ferry for goods wagons.
g = Steam tug.
h = Offices.
i = Waiting room.
k = Dining room.
l = Lunch room.
m = Covered entrance.
n = Electric light and power station.
o = Clinkers.

Fig. 32. — Terminus station of the Pennsylvania, at Jersey City, near New York.

Explanation of German terms : Anlegeplätze der Fähren = Landing stages of ferries. — Aufstellgl. f. Vorortzüge = Marshalling sidings for suburban trains. — Bahnsteighalle = Platform hall. — Exchange-Platz = Exchange place. — Freilade-Verkehr = Roads for loading on. — Gleisverschlingung = Sidings. — Hudson-Fluss = River Hudson. — Kohlenrutschen = Coal shoots. — Ladestrasse f. d. Postverkehr = Road for loading mails. — Landezunge = Landing pier. — Nach d. Fähren = To the ferries. — Nach Philadelphia und zum Abstellbahnhof = To Philadelphia and to the train yard. — Schwimmende Ueberladebrücke = Flying bridge. — Strasse = Street. — Strassenbahn = Tramway. — Strassenbahnen = Tramways.

In the first place, at every terminus station there is the danger that a train may enter at too high a speed, run through the buffer stops and do damage. Consequently more care is required, and therefore a train takes longer to enter than at a through station. Then each train can only be reached from one end; this interferes with shunting and more such operations are necessary. The switches before the station have, for an equal amount of traffic, at least twice as much to do as at a through station. Moreover, if a train is to start again from the station, arranged just as it was before (traffic considerations often make this necessary), the train must be reversed, that is to say, it must be completely taken apart and put together again. Various attempts have therefore been made to give terminus stations some of the characters of through stations.

A simple method, which can, however, only be applied where local conditions are exceptionally favourable, consists in continuing the tracks beyond what would otherwise be their dead ends. Thus figure 33 would become as shown in figure 34; the station then becomes a through station ending in a dead ended siding. This makes the entrance of the trains to the stations safer and quicker, the shunting of locomotives and of whole trains is made easier, and many shunting operations are made much simpler; but what is of special importance, is that switches between the open line and the station have less to do. Such arrangements have been made for instance at the Potsdamer Platz station and at the former “ Knie ” terminus of the Berlin electric Hoch and Untergrundbahn.

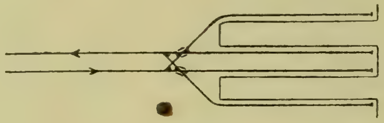


Fig. 33.

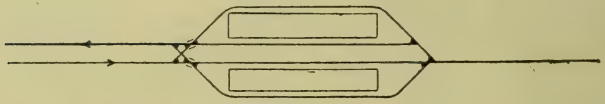


Fig. 34.

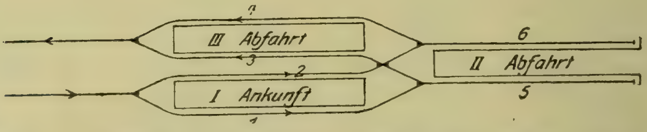


Fig. 35. — Terminus of the elevated on the Brooklyn bridge, New York.

Explanation of German terms : Abfahrt = Departures. — Ankunft = Arrivals.

An instance showing that large terminus stations can also be arranged on this system is given by the chief station of the Illinois Central Railroad at Chicago, previously described (see fig. 21). A peculiar development of the same principle is shown in figure 35, which represents the terminus station of the Elevated going across the old suspension bridge between New York and Brooklyn. The entrance track divides, before the station, into two tracks (track 1 and 2); beyond them is the island platform I used for arriving passengers only. From them the trains are taken to either of sidings 5 or 6, and thence to tracks 3 or 4, between which there is the departure island platform III. Thus arriving and departing traffic is kept quite separate. But as it takes longer for the departing passengers to get into the train than for the arriving passengers to get out, the extra sidings have also a platform between them (platform II), which in order to relieve platform III, is also used as a departure platform.

Another modification in the general arrangement of terminus stations, depends on the provision of triangles; these are especially useful where it is desirable to turn round whole trains before they leave a place again. A very simple instance is shown in figure 36; this represents the Silver Plume terminus of the Colorado and Southern Railroad, which is a narrow gauge line running from Denver into a rich silver-mining district. The arriving trains do not run at once to the platform, but are switched off at *a* and run into the dead ended siding 1; then they go backwards over the *bc* side of the triangle to the platform 2. The train then leaves again, composed and arranged as it was on its previous journey, by the *ac* side of the triangle, no shunting operations having been necessary. It is true that this method of operation involves a small loss of time for the passengers; but this is of little importance on a minor line as compared with the other advantages. If required the triangular movement could be carried out after the passengers had got out; the train would then run in direct over the side *ac* to the platform.

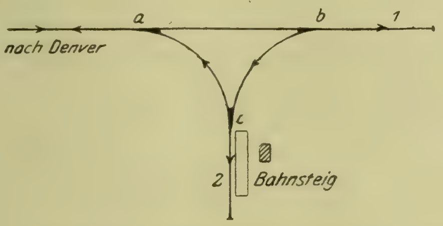


Fig. 36. — Terminus of the Colorado & Southern at Silverplume.

Explanation of German terms : Bahnsteig = Platform. — Nach = To.

This principle, which may be found applied at many American railway stations, is applied on the large scale at the chief station at St. Louis (¹). St. Louis is a centre to which more than twenty different lines run; but these unite long before the station to form an east-west through line. The line passes to the east in a double-track tunnel under the city, and then by a large bridge over the Mississippi, on the other side of which the many lines to the north, east and south branch off. The railway station, which is owned by a separate company, formerly formed an intermediate station on the direct east-west line; but when it no longer sufficed for the growing traffic, a new station was added at right angles, which in accordance with American preferences was designed as a terminus, and the service there was operated in a very

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(¹) *Zeitung des Vereines deutscher Eisenbahnverwaltungen*, 1903, p. 833.

peculiar way. The real fundamental principle of the arrangement of the station is really similar to that of the smaller Silver Plume station, and is shown in figure 37; the trains arriving, coming from *a* on track I, do not run at once into the terminus station, but on to the dead end I*a*, and then back over track III to the platforms; the departing trains run out direct, from the platforms, over track II.

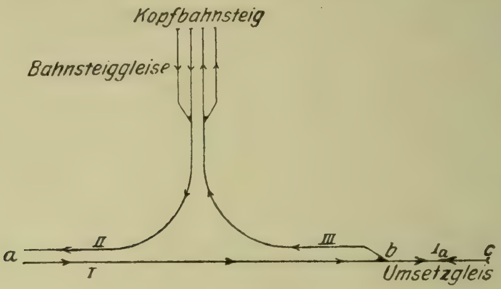

Fig. 37.

Explanation of German terms : Bahnsteiggleise = Platform. — Kopfbahnsteig = End platform. Umsetzgleis = Shunting siding.

An additional advantage obtained in this way, is that the passenger carriages of an arriving train come nearer to the cross-platform, than if the locomotive (with mail and luggage van usually next to it) were in front; moreover, it is easier to deal with the luggage, and the station hall is not dirtied by the smoke of the entering locomotives. On the other hand, this general arrangement has material defects, particularly in the case of large stations, for instance the loss of time resulting from the entrance, the dangerous backing of long and heavy trains round sharp curves, finally provision of more switches and crossings, if lines run into the station from different directions.

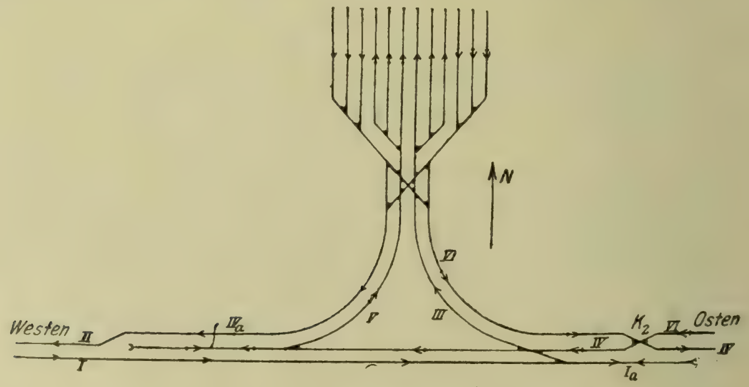

Fig. 38.

Explanation of German terms : Osten = East. — Westen = West.

The St. Louis station, the main principle of which is illustrated in figure 37, is complicated by the fact that both from the east and west lines run into it, which

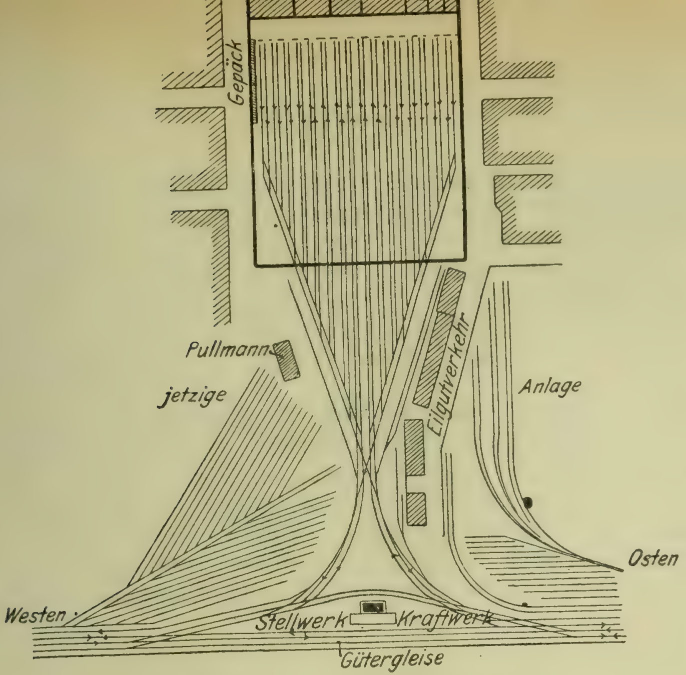

Fig. 39. — St. Louis station before 1903.

planation of German terms : Eilgutverkehr = Express packages. — Gepäck = Luggage. — Gütergleise = Goods tracks. — Jetzige Anlage = Present arrangement. — Kraftwerk = Power station. — Stellwerk = Signal cabin. — Westen = West. — Osten = East.

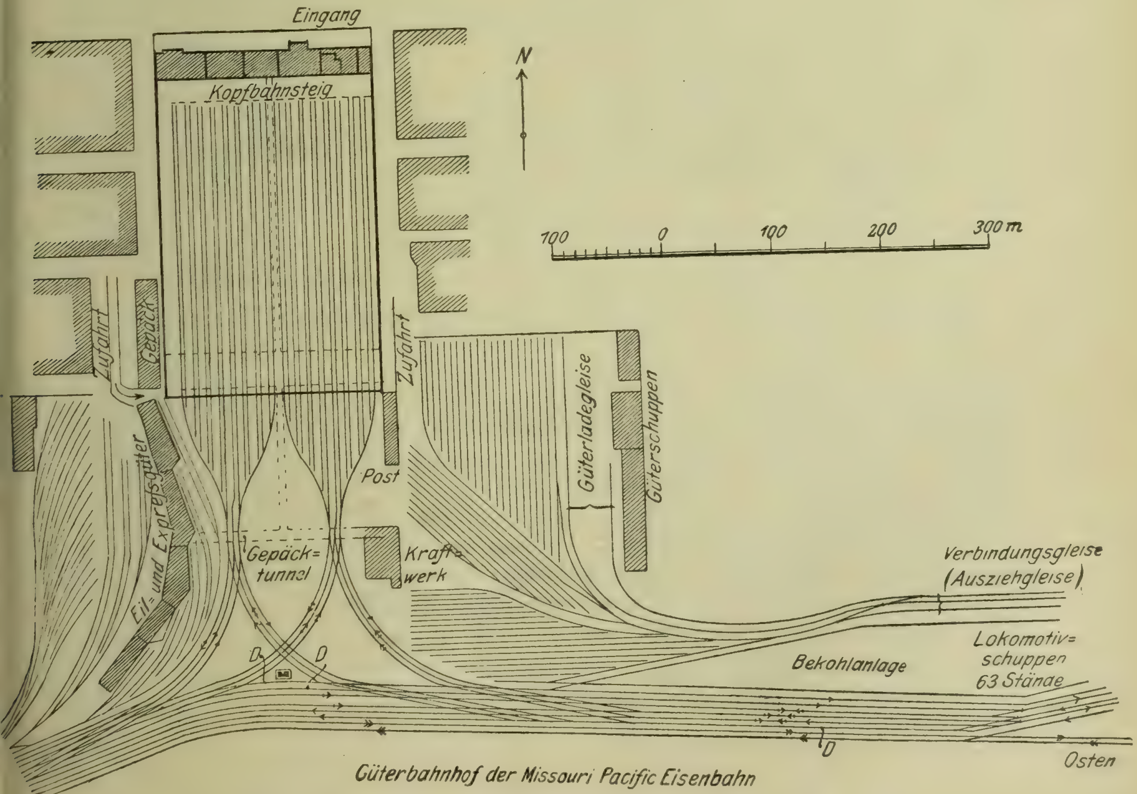

Fig. 40. — St. Louis station, rebuilt 1903.

Explanation of German terms : Bekohlanlage = Installations for supply of coal. — D = Through tracks. — Eil- und Expressgüter = Quick freight and express packages. — Eingang = Entrance. — Gepäck = Luggage. — Gepäcktunnel = Subway for luggage. — Güterbahnhof der Missouri Pacific Eisenbahn = Goods station of the Missouri Pacific. — Güterladegleise = Goods sidings. — Güterschuppen = Goods sheds. — Kopfbahnsteig = End platform. — Kraftwerk = Power station. — Lokomotivschuppen 63 Stände = Locomotive sheds (for 63 locomotives). — Osten = East. — Verbindungsgleise (Ausziehgleise) = Junction tracks (draw-out tracks). — Zufahrt = Approach.

makes it necessary to have at least the arrangement of track shown in figure 38, with two dangerous crossings. The actual arrangement (fig. 39) is on the principle shown in figure 38, but is naturally more complicated as there are other sidings and switches. It was difficult to obtain a definite opinion as to the station and its efficiency, as Americans do not criticize their own arrangements; but we have a general impression that the arrangement does not give satisfaction.

The station was altered and extended as shown in figure 40 for the Exhibition traffic.

The one four-track neck was replaced by two three-track necks; this led, at the same time, to the lengthening of the outer platform sidings, which till then had been only 130 metres (140 yards) long. The arrangements for dealing with the luggage were improved by the construction of a large luggage office and of a tunnel, and the express installations were enlarged; additional sidings were also added. The whole station can be looked upon as a valuable and instructive experiment, rather than as a complete solution of the problem of large terminus stations.

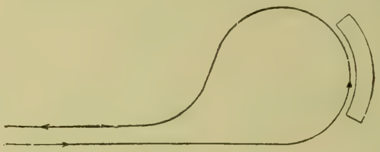

Fig. 41. — Station with loop.

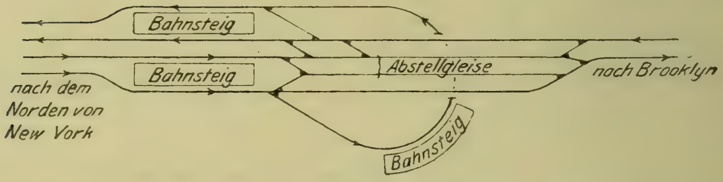

Fig. 42 — City Hall station, on the new underground railway, New York.

Explanation of German terms : Abstellgleise = Sidings for empty trains. — Bahnsteig = Platform. Nach Brooklyn = To Brooklyn. — Nach dem Norden von New York = To the north of New York.

The most important device that has been applied for avoiding dead ends is the loop; in this, as shown in figure 41, each track has no dead end but is continued by means of a loop to the other (¹). This reduces the station in its design and its working to a simple through station, in fact to a very simple one, as there is only one direction of running. As trains can be dealt with just as quickly as at an intermediate station, it is seldom necessary to increase the number of main tracks even if there is very much traffic; but then even this can be done very conveniently and without having crossings. The loop was already in use in Paris, in the early forties, at the terminus of the Sceaux line, but in course of time became forgotten. Such

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(¹) Vide *Zeitschrift für Kleinbahnen*, 1900, p. 601.

loops are very often used for tramways and town lines, but as far as we know not yet for trunk railways; the small curves usual in America, having often on town lines a radius of only 27 metres (1·35 chain), make the frequent use of loops convenient. As an instance we show in figure 42, the City Hall station on the new underground railway of New York; it is however not a true terminus but a combined terminus and through station, as the inner tracks of the four-track line continue to Brooklyn, while the outer ones form a loop under the through tracks. The same principle is applied at Park Street station (fig. 43), the most important station of the underground railway at Boston; here also the four-track line changes into a two-track line.

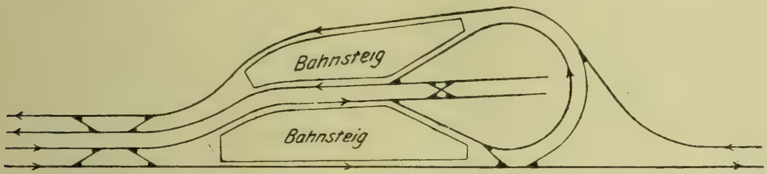

Fig. 43. — Park Street station, on the Boston underground railway.

Explanation of German term : Bahnsteig = Platform.

The most important loop station in America is probably the well-known local terminus station which is located below the Southern Union station at Boston (¹). It will however be surpassed by the new Grand Central Depot of New York, the terminus of the New York Central, where many alterations are now being made in connection with the introduction of electric working. This station (figs. 44 to 47) will be entirely underground as far as its tracks and sidings are concerned; it will, as shown in figure 44, have two floors; the streets which are now level with the track will after this has been lowered run over it. The blocks left between the new streets will partly be used for service offices and buildings; but the greater part will be left clear so that daylight can reach the upper track direct. The station, a plan of which at street-level is shown in figure 45, can, as far as the actual traffic is concerned, be described as a three-floor building. The ground floor (over which there are seven floors more, used as offices) includes an entrance hall, booking offices, and a general hall with an exit hall and a large horseshoe-shaped space for the luggage offices. The floor below the ground floor contains the waiting hall, with large side rooms, and the end cross-platform for the long-distance traffic; the floor below this is a few metres higher than the suburban sidings and contains, in addition to the space used for the mechanical appliances, only the cross-platform for the suburban traffic.

The suburban traffic is branched off from the four-track line, operated according to direction, without tracks carrying trains in opposite directions crossing each other (see fig. 46). The arrangements for the long-distance traffic consist of the

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(¹) Vide *Eisenbahntechnik der Gegenwart,* Bahnhofsanlagen, and *Bulletin of the Railway Congress,* No. 7, July, 1899, p. 923 : " The Southern Terminal Railroad Station at Boston (Massachusetts, U. S. A.) ", by Charles P. Clark.

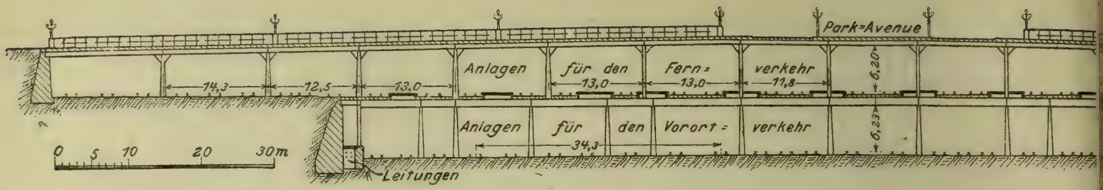


Fig. 44. — Section A-B (figs. 46 and 47) of the new Grand Central Depot at New York.

Explanation of German terms : Anlagen für den Fern-Verkehr = Arrangements for the long-distance traffic. Anlagen für den Vorort-Verkehr = Arrangements for the suburban traffic. — Leitungen = Cables.

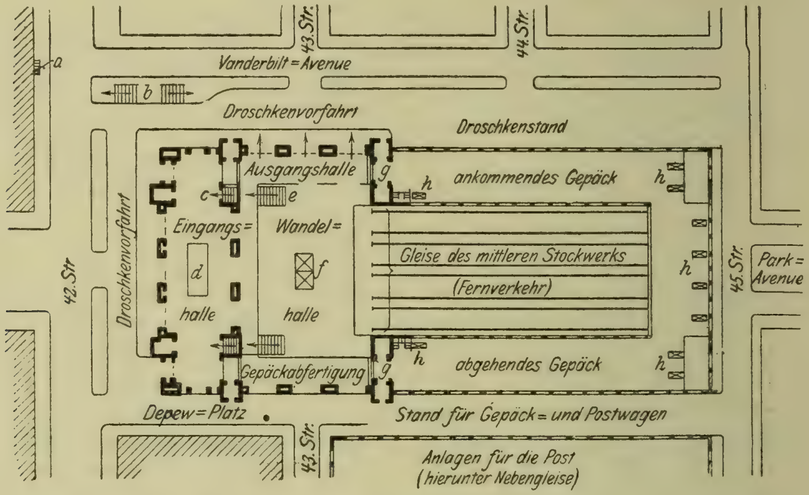


Fig. 45. — The new Grand Central Depot at New York. Floor at street-level.

a . . . . . = Entrance to underground railway.
b . . . . . = Staircase to next floor.
c . . . . . = Staircase to suburban trains.
d . . . . . = Tickets.
e . . . . = Staircase to main-line trains.
f . . . . = Lifts for passengers.
g . . . . = Offices.
h . . . . = Luggage lifts.

Explanation of German terms : Abgehendes Gepäck = Departing luggage. — Ankommendes Gepäck = Arriving luggage. — Anlagen für die Post (hierunter Nebengleise) = Installation for mails (sidings below). — Ausgangshalle = Exit hall. — Droschkenvorfahrt = Approach for cabs. — Droschkenstand = Cab stand. — Eingangshalle = Entrance hall. — Gepäckabfertigung = Luggage office. — Gleise des mittleren Stockwerks (Fernverkehr) = Tracks on intermediate floor (long-distance traffic). — Wandelhalle = Concourse.

platforms and their sidings, the lie-byes for empty trains and the equipment for the mails and express packages. There are nine intermediate platforms each with two tracks; their length varies between 210 and 450 metres (between 688 and 1,475 feet). Several trains can therefore draw up along each of the middle platforms simultaneously; this possibility will no doubt be utilized, at least for departing trains. Except in the case of the two platforms to the west, which will probably be used more for short than for long-distance traffic, all platforms are connected, by lifts, with the luggage offices which are above; with these, they are also well connected, by means of a tunnel (shown in fig. 47) between the long-distance floor and the suburban floor, with the offices dealing with the mails and the express packages. It is true that this connection is rather long, but it is rail-free; and that is very rarely the case in America. There are two additional special luggage platforms for dealing with the luggage. The luggage vans can be on the sidings next the luggage platforms for some considerable time before the departure or after the arrival of the train concerned, and trains carrying luggage and express packages only can there be dealt with.

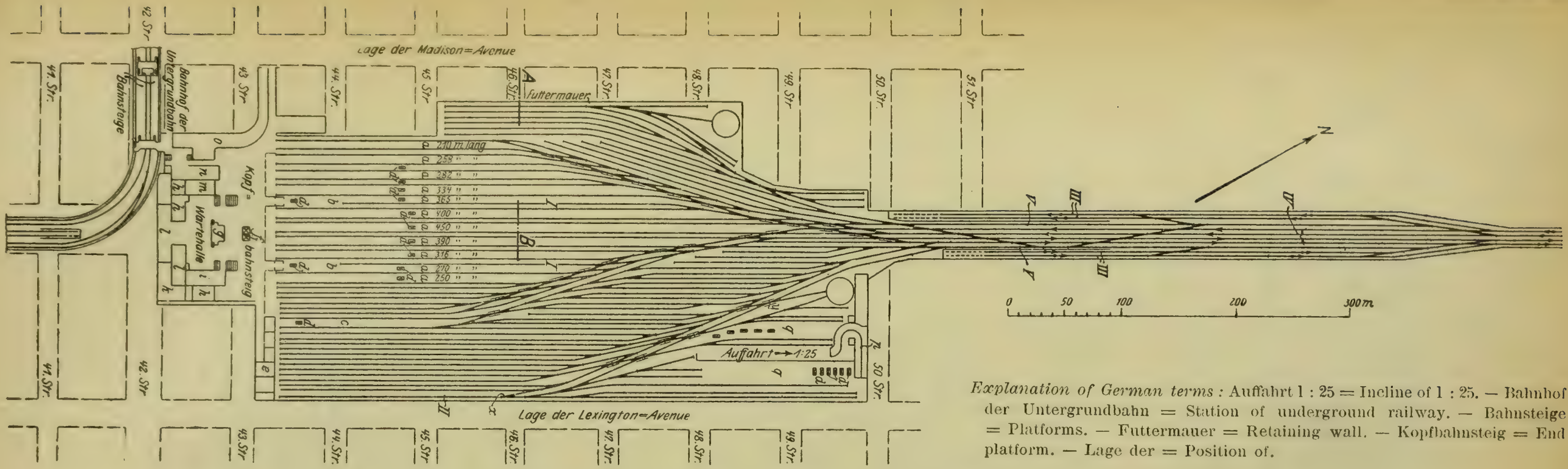
All the platform sidings can be used both for arriving as well as for departing trains; but those to the west are to be used chiefly for arrivals, those to the east for departures. A note-worthy point about the switch arrangements is that the necks usual elsewhere are avoided, and that as a double set of switches is provided, it is possible for a train to start from any of the sidings, while another train at the same time is arriving on the track next to the west. Such a systematic attempt to obtain the greatest efficiency in operation of traffic is only to be found at few American stations, such as Broad Street station, Philadelphia, and the chief station of the Pennsylvania at Pittsburg; these we have already described.

The space available on the two sides of the platforms is utilized for numerous lie-bye sidings. All of these can be reached by two tracks which extend between 51st and 55th street on both sides of the main tracks, and are connected with all the station tracks. Most of the sidings for empty trains are dead ended; there are only eleven connected at both ends, although this would have been possible with more. Shorter marshalling sidings are absent, so that trains are re-arranged in the "points" of the other tracks. The total length of the sidings for empties is 27 kilometres (16·8 miles), so that over a hundred trains can stand on them at once. In them, if some of the cross-overs and through tracks are also utilized, five shunting locomotives can effect any re-arranging operations without hampering each; and that would be enough. The object of the turn-tables is unintelligible to us, as the trains are going to be hauled by electric locomotives exclusively, and these do not require to be turned. The old train yard Mott Haven, which will be described later on, will be materially relieved by this alteration; but it will not be possible to do without it altogether.

The arrangements for the express package traffic between 48th and 50th Street, are reversed, that is to say, the dead ends of these sidings are to the north, whereas the dead ends of the other sidings like those of the main lines are to the south. This arrangement, which makes it necessary to reverse the position of the shunting locomotive, was necessary if the available space was to be utilized to best advantage. The shunting of the cars and the change of the relative position of the locomotive is effected by the tracks and switches marked x and y on the plan, figures 46; the necessary siding to pull out into, which must have its dead end to the south, is made of sufficient length. The goods sheds of the express companies are at street level and are connected with the loading up sidings with lifts; there is also an inclined street approach down to them. The offices for dealing with the mails are also at street level; they occupy the ground floor of the new many-floored general offices of the railway company. A platform and two tracks are provided for loading up the mails; those are connected with the mail offices above by a lift.

The tracks for the suburban traffic (see fig. 47) are below those for the long-

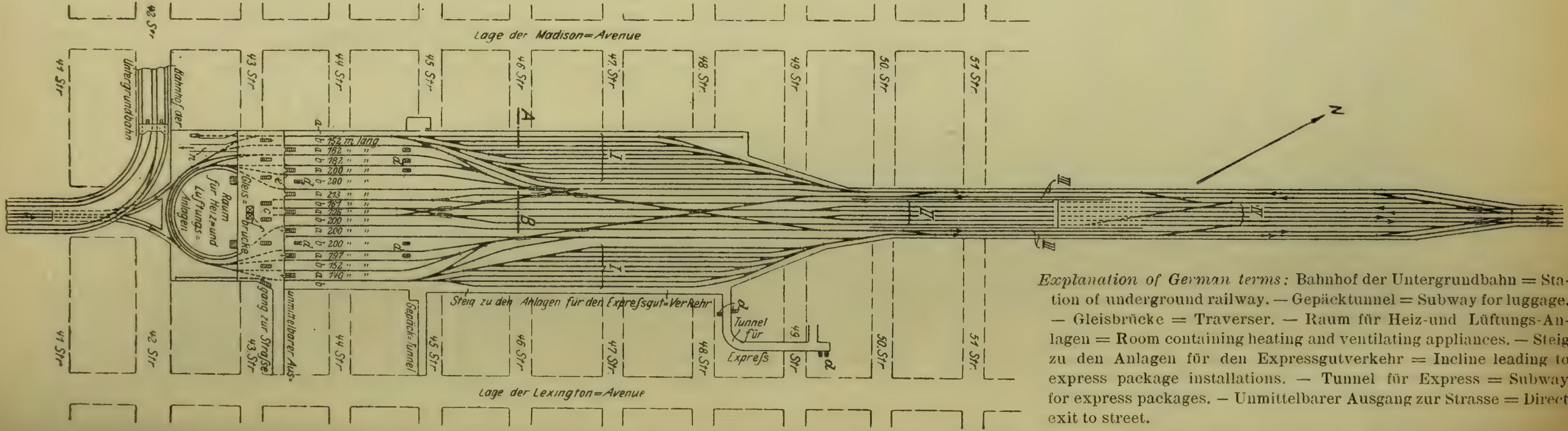
Figs. 46 and 47. — The new Grand Central Depot at New York.



Explanation of German terms: Auffahrt 1 : 25 = Incline of 1 : 25. — Bahnhof der Untergrundbahn = Station of underground railway. — Bahnsteige = Platforms. — Futtermauer = Retaining wall. — Kopfbahnsteig = End platform. — Lage der = Position of.

Fig. 46. — Plan of intermediate floor. Main lines.

a = Passenger platforms.
b = Luggage platforms.
c = Mail platforms.
d = Luggage lifts.
e = Offices.
f = Passenger lifts.
g = Cloak room.
h = Lavatories.
i = Waiting room for ladies.
k = Kitchen.
l = Refreshment room.
m = Smooking room.
n = Inclines to suburban station.
o = Cab stand.
p = Inclined approach to sidings used by express companies.
q = Platforms for loading express packages.
I = Sidings.
II = Draw-out track for express package service.
III = Chief suburban lines, with southwards falling gradients.
IV = Chief main lines.
V = Draw-out track for main line service.



Explanation of German terms: Bahnhof der Untergrundbahn = Station of underground railway. — Gepäcktunnel = Subway for luggage. — Gleisbrücke = Traverser. — Raum für Heiz-und Lüftungs-Anlagen = Room containing heating and ventilating appliances. — Steig zu den Anlagen für den Expressgutverkehr = Incline leading to express package installations. — Tunnel für Express = Subway for express packages. — Unmittelbarer Ausgang zur Strasse = Direct exit to street.

Fig. 47. — Plan of lowest floor.

distance traffic. Only the three middle ones have dead ends; the six tracks to the west are continued, and join to form a two-track loop which again extends into the six tracks to the east. Accordingly the three middle tracks can be used for both arrivals and departures, as may be most convenient, but the six tracks to the west, have all their switches arranged so as to serve for arrivals only; the six tracks to the east, for departures only. But the large system of switches before the entrance makes it possible to use all the tracks both for arrivals and departures. All switches are arranged so that the main line retains its four-track character right into the station; this alone is already conducive to great efficiency. It is still further increased by the provision of more through train platform tracks, 2 × 6 in number, for this makes it possible to keep a train on arrival as well as departure, three times as long as the train-interval on the main line. The terminus station thus makes it possible to have considerable variations in the intervals between trains without making it necessary to have any shunting operations.

Each platform siding is between two platforms, so that the platforms (like at large London stations) for arrivals and departures are kept separate. In our opinion this is going too far; for surely in New York, if anywhere, the flow of traffic is such that at one time of day (between 7 and 9 a. m.) the large bulk of it is arriving traffic, and at another time of day (between 5 and 6 p. m.) departing traffic. Thus, just during the busiest times half of the platforms will hardly be utilized. It would probably have been better to have one platform to every two tracks. The platforms are accessible from a cross-bridge, which may be considered a high-level cross-platform, by two sets of stairs; here also arrivals and departures are kept strictly separate.

The sidings for empty trains are, as in the main-line station, in two groups at both sides of the main tracks. They are all connected up at both ends; but the southern connection does not lead to a separate siding but to the external platform track. This double connection would hardly be as necessary with the suburban sidings as with the long-distance sidings (where it is not generally provided), because the suburban trains seldom have to be altered in their composition; moreover as they consist of self-propelled cars no shunting locomotive is required.

The projected connection with the underground railway, which would enable the suburban trains to run through the whole business part of the city and right into Brooklyn, has for the present been abandoned.

III. — Train yards.

When we consider the train yards, that is to say, the localities where the passenger trains are cleaned, examined, made up, in other words, are prepared for their next journey, we have to remember that these yards can be simpler in America than in Germany; for apart from the Pullmann cars, there is only one class in the United States, so that the composition of trains is much more uniform. Moreover, all passenger carriages are eight-wheeled (being on two four-wheel bogies), so that no special precautions are necessary owing to carriages being of different weights;

finally, separate through carriages to different places are very rare in America, while we have an excessive number of such carriages and thereby give our trains an unnecessary length, and the service at junctions and carriage depots is consequently more complicated and expensive. As moreover the post-office requirements are also smaller than in Germany, the whole arrangement of the train yards and the service there are simpler than in the German establishments of a similar size. This is not materially affected by the fact that the American railway companies have to deal at their train yards with and provide accommodation for two or more other companies, namely the Pullmann Company and one or more express companies; for the Pullmann Company replaces our dining, sleeping and saloon car arrangements for which special accommodation is also required in Germany; and the express company accommodation is replaced with us by the quick freight department.

As regards train yards, the Americans have only of late begun to make systematically organized designs, after the question had been investigated by a special commission appointed for the purpose. In most cases, trains yards in America, as in many cases also in Germany, slowly became developed out of small beginnings, by the successive addition of sidings not laid out on any definite general plan, the result being a rather unsuitable arrangement.

As long as there was but little traffic, the platform sidings were also used for marshalling and making up the passenger trains. Later on, separate marshalling sidings were provided, as near to the platforms as possible; these were mostly dead ended, and access to them was obtained from one of the main lines; next to these sidings, there were located the sidings and appliances for the locomotives and for the mail and express traffic. With an increasing number of trains, it then became necessary to increase the number of platform sidings and this necessitated longer connecting lines, so that all or part of the marshalling sidings which were in front of the station had to be removed. Now as just at the most important stations there was but little spare room, as those stations were in the middle of built-over parts of cities, it became necessary to have separate train yards further out, and in many cases, much further out, and this made the service appreciably more costly.

Accordingly, at many of the American terminus stations, the train yards are divided into two parts, one smaller yard near the station, generally just in front of it (see, for instance, fig. 31, La Salle Street, Chicago; fig. 32, Jersey City; figs. 46 and 47, plan of Grand Central Depot, New York, two floors); the main yard is, however, as a rule outside and is connected with the station sidings, either by the main lines or by special tracks provided for the purpose (see Broad Street, fig. 29, with three such tracks).

The smaller yard near the terminus station, is used in the first place for examining, cleaning and keeping those trains which start again very soon; thus it is used principally for local and suburban trains. If there is room available, provision is also made for supplying the locomotives with coal and water and for turning them, so as to save the expensive journey to the main yard. The sidings of this minor yard are nearly all dead ended; consequently, operations are rather complicated; the train locomotive must during the shunting operations run round its train, or if this is to be avoided a special shunting locomotive has to be provided. The arrangement shown in figure 31 and previously referred to (La Salle Street, Chicago) is thus much better, as in this case, a set of sidings is provided on each side of the main line and accessible from it, for local and suburban trains.

The space available in America in front of the station proper, is very limited; in the first place, the express sheds have to be located here, for the peculiar nature of their traffic makes it necessary to have a place for loading, very near to the platforms, so that the preliminary loading can be done at the sheds and the loading completed at the platform, in order that express packages can be received right up to the moment the train starts. While the installations of the express companies are very extensive and in many cases larger than our quick freight stations, the installations for the mails are very small, as the post office conveys practically only letters, postcards, printed papers and samples; not parcels as with us. For instance, at the large terminus station of the Pennsylvania in Jersey City (for New York, see fig. 32) the whole provision for the mails consists of one street, not even under cover, with two tracks alongside; the mail vans are not only loaded and unloaded here, but also cleaned and examined.

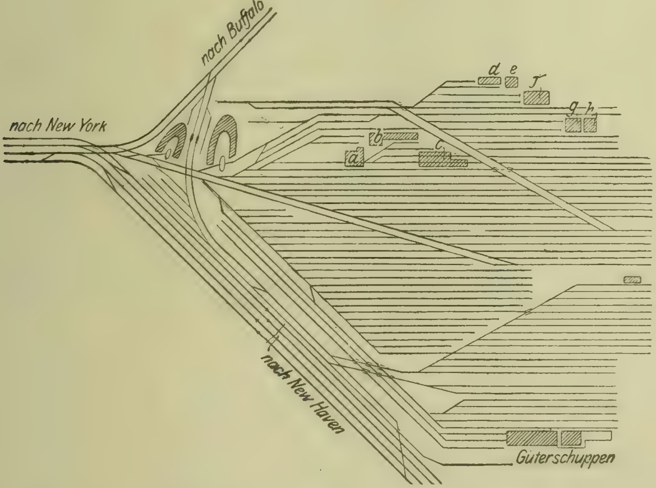


Fig. 48. — Train yard of New York Central at Mott Haven.

a, b, c. . . . . = Workshops and storage rooms.
d . . . . = Canteen.
e . . . . = Boiler house.
f . . . . = House for staff.
g, h. . . . . = Pullman sheds.

Explanation of German terms : Güterschuppen = Goods sheds. — Nach = To.

At the main train yards, which as already stated are often a long way out in the case of large stations, the different arrangements existing with us can also be recognized in America : thus the marshalling sidings for the passenger trains are generally grouped together, and they are connected with the main lines or with special tracks leading to the station. Most of these sidings are dead ended, even in cases where it would have been easy to have connections at both ends; as an instance, we give figure 48, the Mott Haven train yard of the New York Central. The commission mentioned above gives, as an instance of very good design, the train yard of the Pennsylvania at Buffalo (fig. 49); the general plan reminds us of the triangles previously described (compare Silver Plume station, fig. 36). The empty trains from the passenger station run over the main line, which has two tracks only part of the way, but do not diverge at *a* to the sidings. They run on to beyond the switch *b*, are then backed over the curve *bc* to the siding Z, and then run forwards on to the gridiron; they are thus completely turned round and can be used again unaltered. The trains then run over the connecting line and enter the main line at switch *a* and run on to the passenger station. This is known as the " Y-track " arrangement.

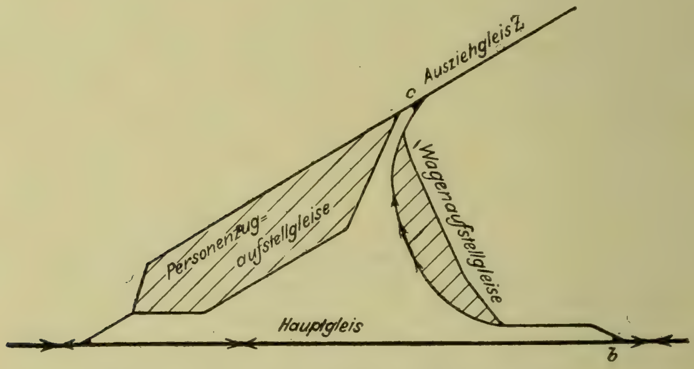


Fig. 49. — Train yard of Pennsylvania at Buffalo.

Explanation of German terms : Ausziehgleis = Draw-out siding. — Hauptgleis = Main line. — Personenzugaufstellgleise = Marshalling sidings for passenger trains. — Wagenaufstellgleise = Sidings for carriages.

Special marshalling sidings are generally absent at most American train depots, just as with us; any operations of the kind are carried out on the points of the train sidings.

Carriage sheds are hardly to be found in America at the train yards for the long-distance traffic. This is the more surprising as it is colder in winter, except in the south, than it is with us; then also such extensive sheds are often provided for city railways and tramways that they can accommodate the whole of the rolling stock. The carriages must, therefore, be cleaned and examined in the open, and the only installations for the purpose consist of a water-supply and of narrow footways between the sidings, which are raised 30 to 60 centimetres (1 foot to 2 feet) above rail-level, and are made of wood. In some cases protection is afforded by a light roof carried on a single row of uprights (see fig. 50). The carriages are cleaned, both outside and in, from these footways, and here also the cushions and coverings taken out of the carriages are beaten and brushed; the state of cleanliness consequently is not always all that may be desired. We did not see in America any devices for cleaning the carriages by compressed air or by vacuum methods (¹); but such may have been introduced since.

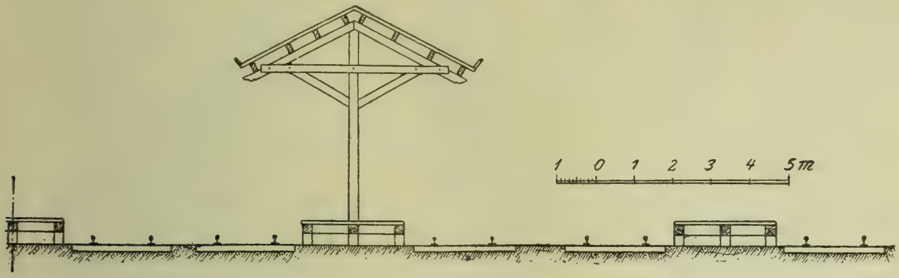


Fig. 50. — Installation for cleaning carriages.

The Pullmann Car Company has at large train yards its own installations for cleaning and maintaining its own cars. It might be supposed that this company would provide sheds for its saloon, dining and sleeping cars, some of which are of great value; but in this case also there are, in the best cases, only light roofs, which often do not extend right over the cars. But there is always a Pullmann office in which the equipment of the cars, particularly the linen, is kept and cleaned, and in which the Pullmann employees sleep.

A noteworthy and important feature of many train yards, is to be found in the workshops, in which even larger repairs are executed and the regular special examinations carried out.

Finally we will mention, owing to the peculiar functions they have to fulfil, the train yards at Croton and North White Plains, of the New York Central; these are at present being built. These are the points at which most of the New York local traffic on the main line to Buffalo and on a less important subsidiary line ends. In addition, all the main line trains change locomotives here, as they are hauled between New York and these two stations by electric locomotives. The suburban trains have electric self-propelled cars. The lines to New York have four and six tracks respectively, and are operated according to direction.

In order to be able to turn round the suburban trains as conveniently as possible, the suburban tracks are, in both cases, connected by loops (see figs. 51 and 52); these loops pass under the lines which go on, so that dangerous crossings are avoided.

The train yard at Croton (fig. 51), the more important of the stations, has two chief groups of sidings, mostly connected at both ends. Group A is specially suitable for the trains in use, whereas group B is more suitable for the reserve trains. Both groups are well connected with the main lines *from* New York by the loop tracks; but the connection with the tracks *to* New York has the disadvantage that the trains have to carry out a shuttle movement in order to reach the platforms. The carriage sheds and the carriage repairing shops will owing to their position

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(¹) Compressed air for blowing out the dust, has been tried at some German train yards without giving satisfactory results; vacuum systems are certainly superior.

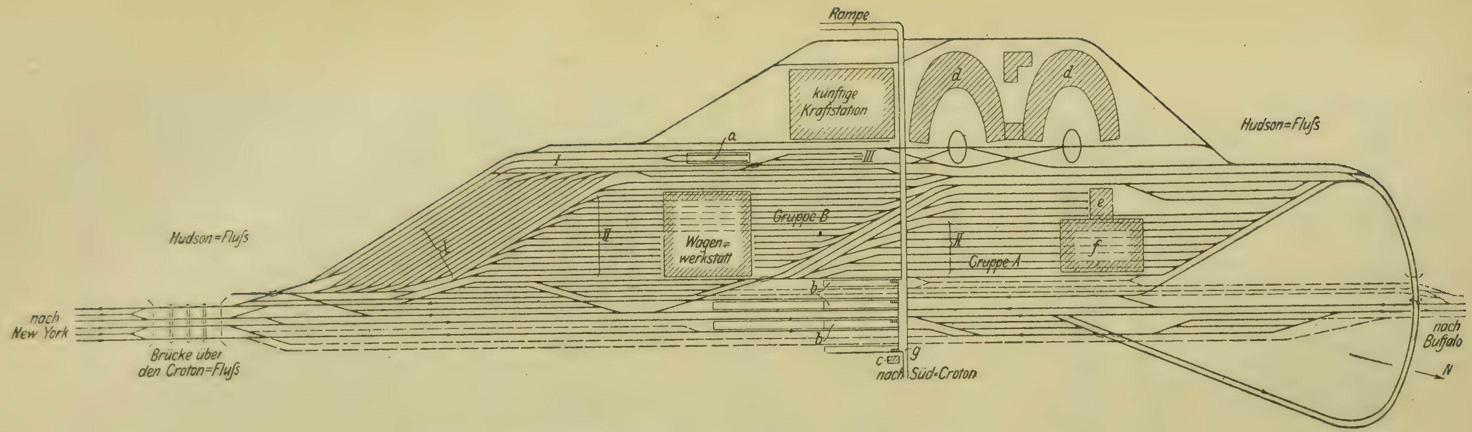

Fig. 51. — Train yard, with loop, of New York Central near Croton.

a = Coal shoots.
b = Platforms.
c = Station building.
d = Locomotive sheds for 30 locomotives.
e = Engine house.
f = Carriage sheds.
g = Bridge across, above rails.
I = Coal sidings.
II = Sidings for empty trains.
III = Sidings for removing clinkers (low-level).

Explanation of German terms : Brücke über den Croton-Fluss = Bridge over the Croton river. — Gruppe = Group. — Hudson-Fluss = River Hudson. Künftige Kraftstation = Future power station. — Nach = To. — Nach Sud-Croton = To South Croton. — Rampe = Incline. — Wagenwerkstatt = Carriage workshops.

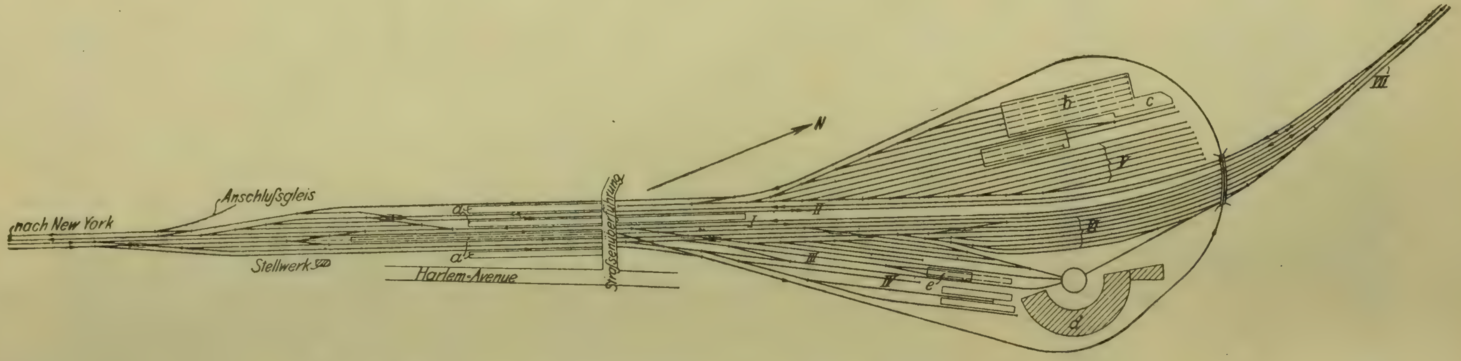

Fig. 52. — Suburban terminus of New York Central at North White Plains.

a = Platforms. | b = Carriage sheds. | c = Store. | d = Locomotive sheds for 25 locomotives. | e = Coal (high-level).
I = Main lines. | II = Goods lines. | III = Ascendings tracks. | IV = Siding for removing clinker. | V = Sidings for empty trains. | VI = Coal sidings. | VII = Draw-out siding.

between the through traffic sidings be rather in the way. The locomotive depot for the steam locomotives consist of two sheds, not of the round-house shape usual in America, but forming two half-circles, as very usual in Germany. The provision for supplying coal is probably, as far as coal sidings are concerned, too ample; the coal is supplied, as usual in America, by shoots located at a higher level. These shoots are filled from hopper cars which are hauled up to tracks located at a sufficient height. Two low-level sidings are provided for removal of clinker. Locomotives in going from the sheds to the platform sidings, have to makes a omewhat complicated journey.

The North White Plains depot (fig. 52) is divided by the passenger and goods main lines which run through it into two parts, for locomotives and carriages respectively, and is consequently rather hampered. The train yard, nearly all the sidings of which are dead ended, can hardly be reached from the tracks *from* New York, so that rather complicated operations are necessary in the case of departing trains. As regards the locomotive sheds and their connection with the platform sidings the same statements apply as made in the previous case.

Unless these plans are still altered before they are carried out, these quite recently designed stations show that American engineers, as we already stated at the beginning of this article, do not yet always pay sufficient attention to the requirements of the traffic.

[621 .33]

ELECTRIFICATION OF THE NEW YORK, NEW HAVEN & HARTFORD RAILWAY,

By E. H. McHENRY,

VICE-PRESIDENT, NEW YORK, NEW HAVEN & HARTFORD.

Figs. 1 to 10, pp. 1159 to 1170.

(*Railroad Gazette.*)

The New Haven Company was one of the pioneers in the field of heavy electric traction, and has operated six of its shorter branch lines by electricity for a number of years past, beginning as early as 1895. Three of these lines, aggregating 33 miles, were equipped for overhead contact, and the remaining lines, aggregating 39 $^1/_2$ miles, for third rail operation. All lines were operated with 500 volt continuous current, supplied from main stations and sub-stations. The third rail was primitive in form and without protective devices of any sort. So many accidents followed the use of this method of supplying current to the motors, that the railroad was compelled to abandon all third rail operation in Connecticut, and revert to steam service, by a decree of the Superior Court dated June 13, 1906, and it now has no third rail in service except a junction overlap with the New York Central at Woodlawn. The unsatisfactory experience with this type of construction, influenced the company's decision in favour of the single phase system for the New York terminal electrification, which was finally adopted after a careful investigation of the relative merits and disadvantages of the two methods of construction.

Had the study of the question been limited to the equipment of the terminal section in New York, considerations of uniformity and expediency would doubtless have influenced the decision in favour of continuous current motors, taking current from a third rail. The New Haven, however, recognized the importance of its decision in its effect on future extensions of electric service to other parts of its system, and the final decision was based upon a study of the subject as a whole, rather than upon the solution of the terminal problem only. The selection of a system of transmission which combines efficiency, flexibility, simplicity and lowest first cost, was important. The New Haven system comprises a network of lines and its transmission problems must be worked out for areas rather than for linear distances, thus reversing ordinary conditions. As the area served increases as the *square* of the radius of transmission from the generating center, the commercial and practical value of high potential transmission is much increased.

While both methods under consideration included high tension transmission by alternating current, it was believed that the combination method requiring transforming devices and continuous current motors was less well adapted to the conditions than single phase for many reasons. The electric efficiency of the combination system between power house bus bars and engine shoes is 75 per cent only, as compared with 95 per cent for the single phase system. The flexibility of the combination system is impaired by the limited radius of the secondary low tension distribution, requiring sub-stations at frequent intervals, and still further by the limitations imposed by the use of a third rail. The position and height of this rail must be rigidly maintained, and the practical margin of permissible variation is small. Its continuity is broken at switches and crossings by frequent transferrence of the conductor rail to the opposite side of the track, or to an overhead position. In contrast, the single phase system requires no sub-stations or secondary circuits; the continuity of the overhead conductor is complete, and its position and height may vary within vertical and horizontal limits of 8 and 4 feet, respectively, without losing contact with the collecting shoes on the pantagraph frames.

It is yet too early to furnish definite and positive comparisons of cost of the two methods under consideration, but the calculations and experience of the company's engineers indicate that the total cost of a single phase installation will be much less than that of the continuous current system, and that the higher electrical efficiency, lower fixed charges, maintenance and operating expenses of the single phase system all tend to reduce the relative cost current delivered to the engine shoes in about the same proportion.

The determination of the most economical and desirable frequency and voltage of the transmission system involved the consideration of many factors. The choice of frequency was limited to 15 or 25 cycles. The lower frequency afforded a material reduction in weight, size and cost of motors, a reduction in conductor losses and induction disturbances, together with an increase in the power factor of the motors, but its adoption would have materially impaired the commercial value of the system as a whole, in restricting or preventing its extension for many other uses incidental to railroad operation. The standard frequency in general use is 25 cycles, and as the New Haven already owned a number of power houses generating current at this frequency for trolley operation, and, in addition, had equipped many of its shops with 25-cycle motors, the adoption of 15 cycles would have required the abandonment of a large amount of standard apparatus, or the interposition of costly and inefficient means of translation. It was also considered desirable to provide for operation in parallel with the 25-cycle generators already adopted by the New York Central. The practical effect of a change from 25 to 15-cycle apparatus, was thus substantially equivalent to a "break in gage," and it was decided that the practical commercial value of the higher frequency outweighed the theoretical merits of the lower one.

Various alternatives were considered before fixing the generating and transmission *e. m. f.* of the system. It was at first proposed to increase the economical radius of transmission to the utmost by generating current at the highest initial voltage for which generators could be safely designed (about 22,000 volts), and to provide sub-stations at suitable intervals, equipped with static transformers, for supplying current at 3,000-6,000 volts to secondary contact circuits. As the two motors in each electric locomotive truck are permanently connected in series, current must be supplied at 560 volts through the transformer, which form part of the locomotive's equipment. It became evident, however, that a great gain in simplicity would result if the intermediate substations and line transformers could be cut out altogether by reducing the initial *e. m. f.* to 11,000 volts and raising the ratio of the locomotive transformer to correspond. This was done with a resulting reduction in capital and operating cost, coupled with an increase electrical efficiency. Incidentally, the difficulties in designing satisfactory collecting devices were greatly diminished.

Before giving a detail description of the apparatus used in the electrified district, it may be interesting to give a few comments on the commercial aspects of electric traction, as the natural prejudice of the stockholder in favour of the continued maintenance of dividends must be respected, and the technical expert too frequently neglects this in his scientific ardor.

Numerous analyses and comparisons of the comparative costs of electric and steam operation have been published from time to time, which tend to prove that a considerable saving in fuel, engine repairs and other operating expenses may be expected. Under favourable conditions, this saving may be large enough to pay interest and other fixed charges on the additional construction investment, and still leave a satisfactory margin to be applied to dividends. Under general conditions, however, it is altogether improbable that the direct saving resulting from the simple substitution of electric for steam power will be sufficient to justify the additional investment and financial risk.

In changing the method of motive power on existing railroads, the conditions are by no means so simple as in the construction of new lines, since a great amount of capital already invested must be sacrificed, and the problems of adaptation to existing conditions are peculiarly severe. The transition stage in bridging over the gap between steam and electric operation, is both expensive and difficult, as the change affects train lighting and heating, telegraph and telephone service, signaling and track maintenance, for which both temporary and permanent provision must be made. The simultaneous maintenance of facilities and working forces for both steam and electric service within the same limits, will rarely be profitable, for the reason that a large proportion of expenses incident to both kinds of service is retained, without realizing the full economy of either.

To secure the fullest economy, it is necessary to at least extend the new service over the whole length of the existing engine district, and to include both passenger and freight trains.

The application of electric traction to heavy railroad service will probably be governed by other and more important considerations than its mere relative cost as a motive power under similar conditions, as illustrated in the development of the ordinary trolley service. In this development, the commercial value of higher speeds and of increased car capacity is so large, that the relative cost of electric versus animal tractive power becomes almost negligible by comparison. Analogous results may be hoped for in the corresponding development of electric traction in heavy railroad service, as the new conditions will afford opportunities for at least two radical modifications of existing conditions, quite apart from minor economies:

In steam service, the weight and speed of trains are limited by the horse-power capacity of the locomotive, which generates its own power, and there are but few locomotives which can generate sufficient steam to utilize their full cylinder tractive power at speeds in excess of 12 miles an hour. Consequently, any increase of speed beyond certain limits can only be attained by sacrificing train tonnage in a corresponding degree. The division of the train-mile cost by the lesser number of tons increases the ton-mile cost proportionately.

The high cost of fast freight service is principally due to this effect of a diminishing divisor, while it would seem that electric traction should permit high speeds without sacrificing commercial tonnage, as, with a relatively unlimited source of power at command, the maximum drawbar pull permitted by the motor design, may be maintained at all speeds.

Hardly less important is the opportunity afforded for the economical operation of trains of *minimum* capacity. The train capacity cannot be reduced, without loss, below the point where the earnings equal the train-mile cost, and if this cost cannot be reduced proportionately with reduced capacity, the inferior limit of capacity may be uneconomically large. In steam service, the irreducible elements entering into the train-mile cost are so large that it is rarely profitable to operate trains earning less than 40 to 50 cents per mile. In contrast, electric service permits an extreme reduction of the train length to single car units, costing to operate but 10 to 15 cents per car-mile. Hence, the frequency of service may be increased and rates reduced, which in turn will react on the volume of traffic, with the final result of increasing both gross and net earnings. It may, therefore, be claimed for electric traction, that it will extend the limits of profitable operation of high-speed heavy trains, and also of light trains of low capacity.

Other but relatively minor advantages are possible in the effect on earnings, due to the elimination of smoke, gases, dust, cinders and heat, the better ventilation of cars, the extension of electric train lighting and heating; and of the effect on expenses due to the concentration of power production in large and economical power houses, a reduction of engine repairs, an increase of effective engine and train mileage, a more or less complete elimination of engine houses, turn tables, fuel stations, water tanks, cinder pits and other operating facilities, the consolidation of power requirements for traction, pumping, operating shops, elevators and general uses, and the use of current for lighting switch lamps, stations and other buildings.

Finally, the availability and value of real estate and structures at large terminals will be greatly augmented by the possibilities of using two or more super-imposed track levels, as in the new terminals in New York for the New York Central and the Pennsylvania.

A general change from steam to electricity will render unproductive a very large amount of invested capital, and create the necessity for the expenditure of additional amounts still greater, but there is no reason to doubt that the transition already in progress will be rapidly extended and applied at all points where congested terminals, high frequency of train service and low cost of power create favourable conditions.

Overhead line construction.

The overhead line construction is of the catenary type and consists of two steel cables of high strength, supported at intervals by steel bridge structures. A copper conductor or trolley wire is suspended below the two supporting cables by means of hangers placed at frequent intervals. Wherever the cables pass over the steel supporting bridges they rest on porcelain insulators, and at intervals heavy bridges are provided against which the cables are anchored by means of specially constructed strain insulators.

The steel supporting bridges are of varying lengths so as to accommodate four, five, six or as many as 12 tracks, as the local conditions require, without placing posts between tracks. These bridges are of a uniform design, and consist of angle iron and lattice bar construction. The anchor bridges are provided with automatic circuit-breakers by means of which the different sections may be isolated, and also the several parallel tracks separated from one another in case of accident to any one track. The anchor bridges also carry lightning arresters, shunt transformers for operating the circuit-breakers, together with foot walks, hand railings, lighting circuits and the wires and conduit for the auxiliary control circuits.

The main conductors over the running tracks are paralleled throughout their entire length from Stamford to Woodlawn by two feeder wires. These feeders constitute auxiliaries to the main track conductors and are connected with the latter at each anchor bridge through circuit-breakers. The auxiliary feeders provide means for feeding around any one section in case it is cut out of service on account of some accident in that particular section.

In laying out the bridges for the section from Woodlawn to Stamford, it was found that the sharpest curvature was 3°. As this curvature will permit of stringing trolley wire in straight lines between points of support 150 feet apart without deviating from the center of the track more than 8 $^1/_2$ inches on each side, it was decided to place all bridges a fixed distance of 300 feet apart, and on curves to provide guide poles from which pull-over wires are attached and secured to the catenary spans. By this means, a minimum amount of overhead wiring was obtained, and the deviation from the center of the track was maintained within safe limits.

The standard four-track intermediate bridge consists of two supporting side posts and a horizontal truss. Each supporting post is approximately 38 feet long by 1 ft. 10 in. square. Each is composed of four 4-in. × 4-in. × $^7/_{16}$-in. angles, secured together by 2 $^1/_4$-in. × $^3/_8$-in. lacing bars. Each post rests on a concrete foundation. The cross truss is bolted to the vertical posts, allowing a distance of 23 ft. 4 in. from the lower side of the truss to the top of the rails. The truss is 4 ft. 6 in. deep from back to back of the upper and lower chord angles, which are placed 1 ft. 10 in. from back to back. The upper chord angles are 3 $^1/_2$ in. × 6 in. × $^3/_8$ in. and the lower are 4 in. × 3 $^1/_2$ in. × $^5/_{16}$ in.

The extensions of the side posts above the trusses are utilized for supporting the feeder wires which are carried on angle iron cross arms bolted to the posts. The lower cross arm carries the auxiliary feeder. The upper cross arm is located 5 feet above the lower one and carries two wires of three-phase circuit. The third wire of the three-phase circuit is carried on a light vertical channel iron support which is not shown in the illustration.

Anchor bridges of heavy construction are placed every 2 miles, and against these bridges the catenary cables are anchored. The auxiliary apparatus and signals are mounted on the bridge, the semaphore blades being located below the truss, so as to afford an unobstructed view to the engineer. The four-track anchor bridge consists of two A-shaped posts having a spread at the base of 15 feet and a width at right angles to the track of about 2 feet. The main members of the posts consist of 6-in. × 4-in. × $^5/_8$-in. angles. These posts are also extended above the truss for carrying the feeder wires. The truss is bolted to the side posts, allowing a clearance above the rails to the lower side of the truss of 24 ft. 3 in., and is 4 ft. 6 in. deep by 5 feet wide between the backs of the chord angles. The upper chords consist of 8-in. × 8-in. × $^9/_{16}$-in. angles, and the lower chords consist of 4-in. × 3 $^1/_2$ in. × $^9/_{16}$-in. angles.

A ladder is provided on one of the posts leading to a small platform at the end of the truss. This platform is provided with a hand rail and carries upon it a box containing an 11,000-volt, low-equivalent lightning arrester A portal is provided in the end of the truss, by means of which the attendant may step to the platform supported upon the lower chord of the truss. From this platform, access is provided to the short ladders leading to the signal lanterns and a second short ladder extending up to another platform supported upon the upper chord of the truss. This platform is surrounded by a hand rail which is also attached to the iron supporting frames of the circuit-breakers, in such a manner that the attendant can in no way come in contact with the live parts of the circuit. At each end of the truss, a 5-kilowatt, 11,000 volt, shunt transformer is provided, one of these being connected directly into a bus-bar which runs around the outside of the circuit-breakers and which is supported on porcelain insulators and bus-bar brackets secured to the upper chords of the truss. The other transformer is connected directly to one of the "power" feeders. As the "power" feeder is connected to the third phase of the generating system, this provides means for operating the switches in case of acci-

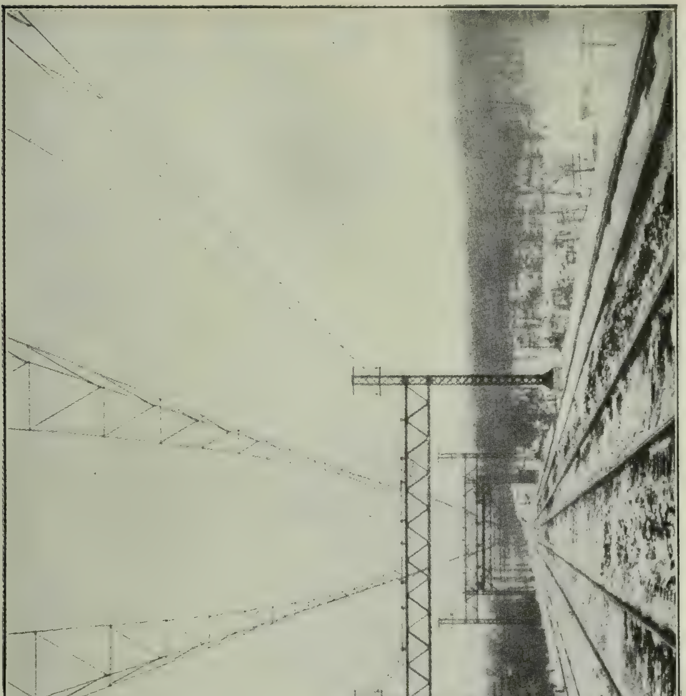

Fig. 1. — Overhead catenary construction over four tracks, New York, New Haven & Hartford.

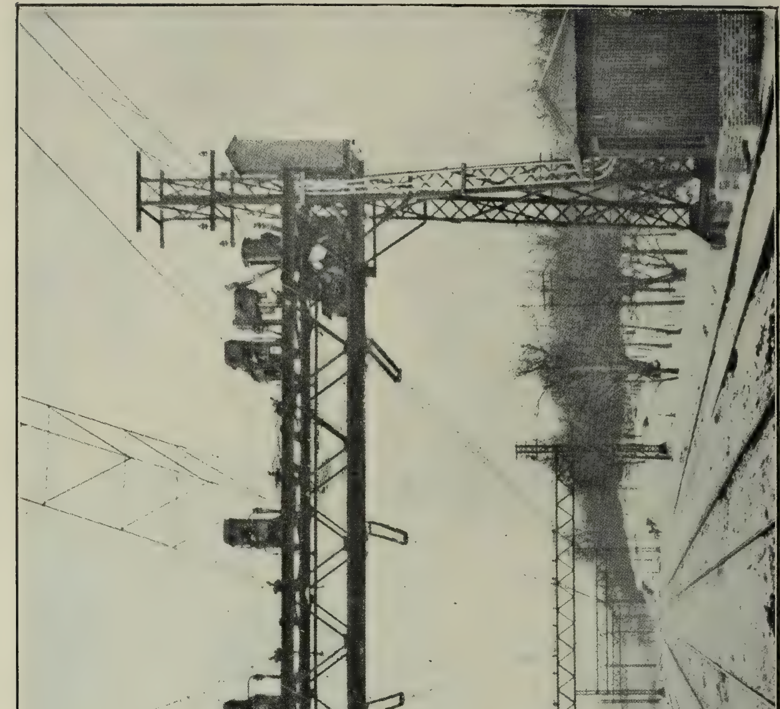

Fig. 2. — Four-track anchor bridge with circuit breakers and section breaks.

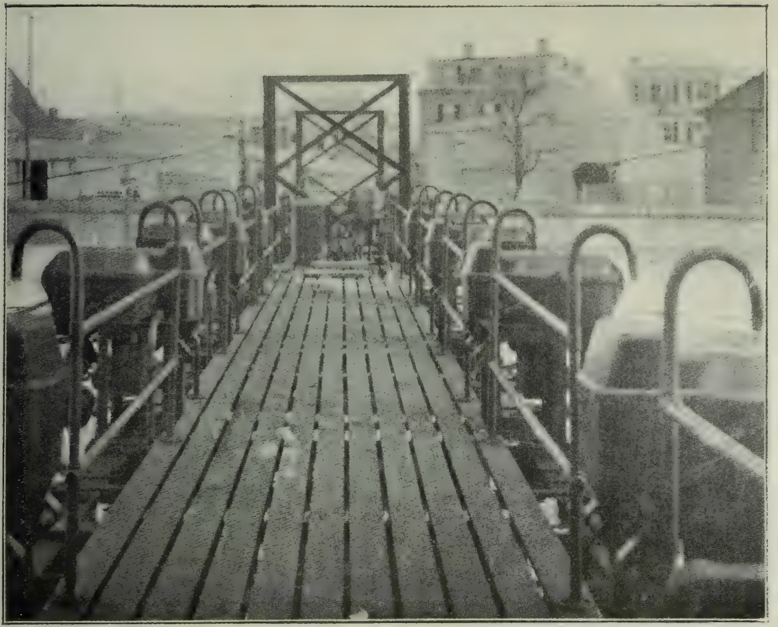

Fig. 3. — Deck of anchor bridge, showing circuit breakers and other auxiliary apparatus.

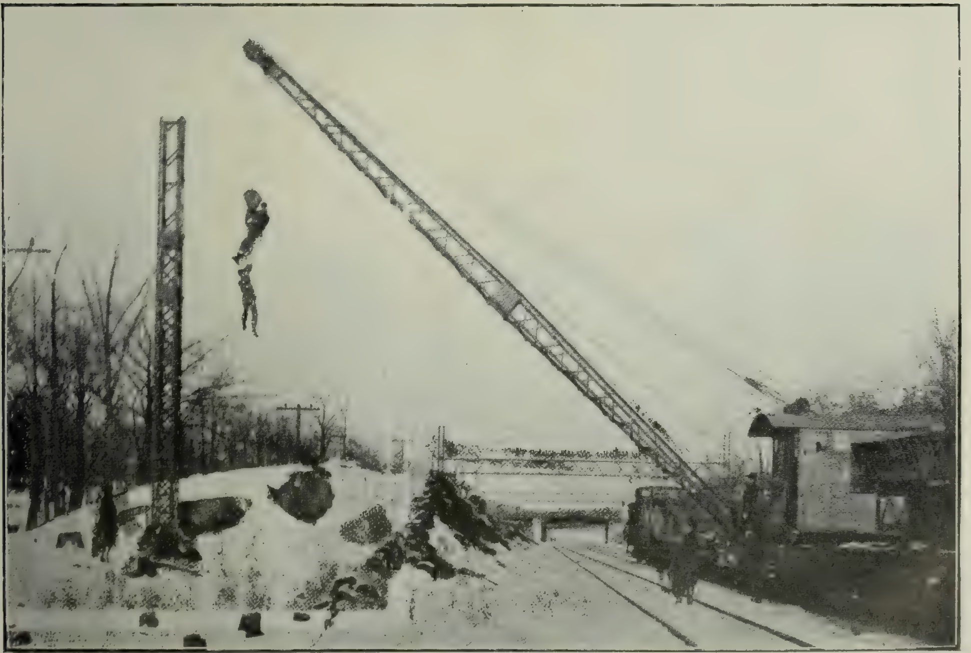

Fig. 4. — Method of erecting bridge columns with locomotive crane.

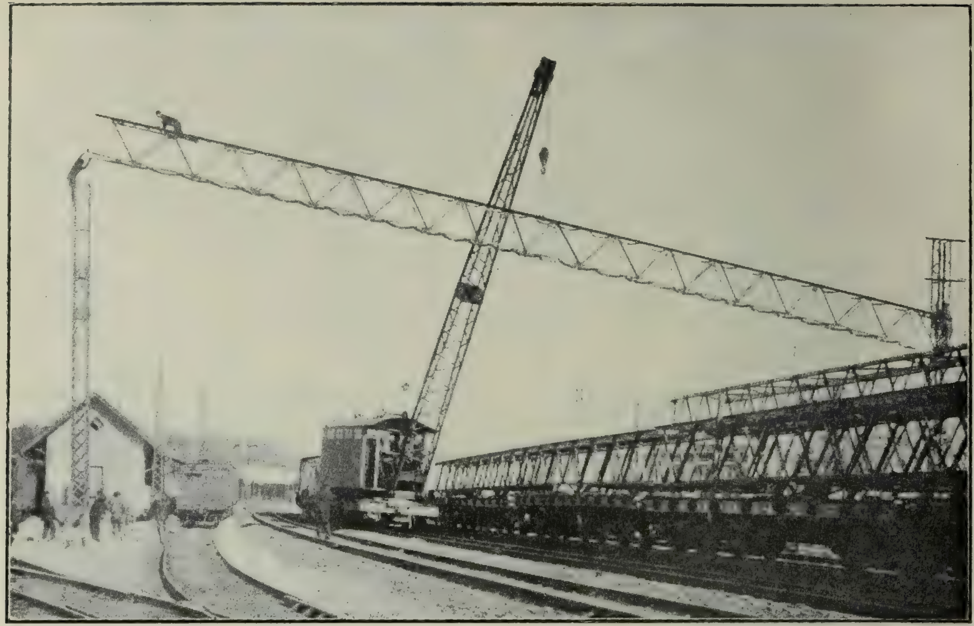

Fig. 5. — Erecting a long trolley bridge truss in the yards.

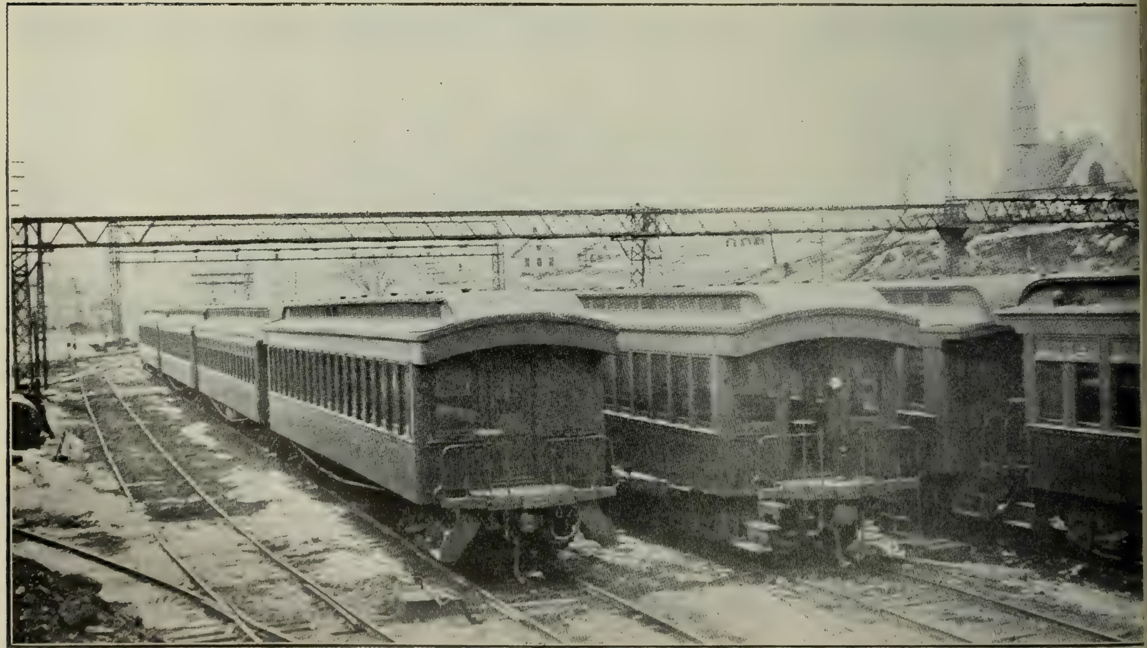

Fig. 6. — Special trolley bridge over yard tracks.

dent to the trolley section. The four-track anchor bridge is secured to concrete foundations by long anchor bolts and nuts.

Each of the two catenary cables which support the copper trolley conductor, consists of an extra high strength steel cable, $^9/_{16}$ inch in diameter, consisting of heavy strands. This steel has an ultimate strength of about 200,000 lb. per square inch, and each strand is heavily galvanized. The completed cable has an ultimate strength of 33,800 lb. These cables are strung between the bridges, with a sag at mean temperature of 6 feet in a standard span of 300 feet.

The trolley wire, which is No. 0000 grooved copper, is supported every 10 feet from the catenary cables by triangular trolley hangers of varying lengths. These hangers are so adjusted in length that the trolley wire is maintained in a horizontal position, 6 inches below the catenary cables at the middle point of the span. They consist of a pair of small drop forged steel jaws, which engage with the grooves of the trolley wire and are clamped by means of a malleable iron Y which is screwed down upon the threaded portions of the jaws. The sides of the triangle are then screwed into the Y and are bolted to the messenger cable above. As all of the treads are right-hand, it is impossible for the hanger to come loose.

At each anchor bridge it is necessary to provide an insulator and a trolley wire, and this is accomplished by means of two bronze end castings to which the ends of the trolley wire are bolted. Two parallel sections of impregnated hard-wood are fastened to these castings, and to these wooden strips are fastened renewable pieces of trolley wire in such a manner that the ends of these renewable pieces overlap one another. By this means, the sliding contact on the locomotive passes from one section to the next without opening the circuit, thus avoiding all flashing.

At a number of points along the road, overhead bridges reduce the clearance above the tracks, and at these points special construction is used. This construction consists of a long corrugated porcelain tube mounted on an iron pipe carried by means of pipe fittings from the lower side of the bridge. The messenger cables where they pass under the bridge are heavily insulated, and the hangers which support the trolley wire from the messenger cables, are placed midway between the porcelain insulators so that the maximum amount of flexibility is obtained. The trolley wire hangers are of impregnated wood so that the trolley wire is completely insulated from the catenary cables. A waterproof shield is attached to the bridge above the insulating structure to prevent accumulations of dirt and water on the insulators.

At a number of points where there are numerous side-tracks, it is necessary to provide extra long bridge supports. An illustration shows one of these long bridges, which is designed to cover twelve tracks. The catenary cable insulators are attached to the lower member of the truss. Both rails of all tracks are bonded with No. 0000 compressed terminal flexible bonds placed round the fishplates.

Wherever one track diverges from another, a section insulator is inserted in the trolley wire. Insulators are inserted in the catenary cables supporting the diverging wire between parallel tracks.

The diverging trolley wire is connected to the main wire by a frog of standard design, and in order to prevent the contact shoes on the locomotive from catching, deflector wires are placed in the angles between the two trolley wires. These deflectors are carried by yokes screwed to the trolley wires, and to yokes at the ends fastened to the catenary hangers. These deflectors are raised at each end so that the collector shoe cannot catch over them.

Electric locomotives.

The specifications under which the locomotives were built, require that they shall be able to handle a 200-ton train on the most severe schedule in the present time-table, corresponding to the local express which stops about every 2·2 miles and operates on a schedule speed of over 26 miles an hour. This requires a maximum speed of about 45 miles per hour. The locomotive is also to haul this weight of train at 65 to 70 miles per hour and a 250-ton train at 60 miles per hour in the long runs. Three 100-ton, or even heavier, trains may also be handled on the long runs at reduced speeds. Heavy trains may be operated at high speeds by coupling two or more of the locomotives together and operating them on the multiple-unit system.

The design of the locomotives was largely dictated by certain requirements : *a*) Gearless motors having a flexible drive and with all the weight carried on springs were desired and finally adopted as the most desirable form, and *b*) operation on 600 volts direct-current necessitated the use of four motors in order that they might be operated in the usual series-parallel relation.

The bogie truck type was adopted after careful consideration as the one best adapted to meet the conditions imposed. Its riding qualities are the best, and it offers the least resistance in taking the curves in the line. The locomotives are 36 ft. 4 in. over bumpers and weigh approximately 90 tons.

The mechanical parts of the locomotive were built by the Baldwin Locomotive Works from designs developed with the co-operation of the Westinghouse Electric & Manufacturing Company and the New Haven engineers.

The longitudinal members of the frame consist of deep plate girders reinforced at the top by channels, and at the bottom by heavy angles and plates. To these frames are riveted plate cross members, one over each truck, forming the transoms. These transoms are further braced by gusset plates riveted to the bottom flanges of both sets of channels, which transmit the tractive power from the center-pin to the side frames. The side girders are placed outside the wheels as low down as the wheels and drawhead will permit, and are braced and squared by substantial steel flooring plates which are riveted to the top flanges. The drawbar effort is transmitted to the side frame through deep box girders joining the frames at the ends of the locomotive. The cab is built up on a framework of Z-bars which are riveted to the side girders. This forms a light but strong construction, able not only to transmit large drawbar pulls but to resist heavy shocks in bumping.

The running gear consists of two trucks, each mounted on four 62-inch driving wheels. The trucks have side frames of cast steel to which are bolted and riveted pressed steel bolsters which carry the center plates. A strong construction is secured without excessive weight by the use of bolsters 30 inches wide at the center plate and extended to nearly double that width at the ends where they are bolted to the side frames. Center bearings 18 inches in diameter transmit the tractive effort to the frame. They are well lubricated to permit free motion on curves. The weight on the journal boxes is carried by semi-elliptic springs. Under the ends of the equalizer bars are small spiral springs to assist in restoring equilibrium. The distance between truck centers is 14 ft. 6 in.

The motors are of the gearless type. The hollow shaft of the armature is made in two halves. These two halves are alike and each is provided with an end disk from which project seven hollow pins. Each half is forced by hydraulic pressure into the ends of the hollow armature spider and is securely keyed in place. The armature and quills are mounted on the locomotive axle. The split housings at each end of the armature carry the armature bearings and are rigidly clamped to the outer field frame of the motor. On each end of the locomotive axle, is mounted a 62-inch driving wheel in the hub of which are formed seven circular pockets which contain helical springs for assisting in carrying the weight of the motor and for transmitting the torque from the armature. Into each of these pockets, there projects one of the hollow pins on the end of the armature shaft. Each pin is surrounded by a spring placed between the outer circumference of the pin and the inner circumference of the pocket. This spring is arranged so as to tend to hold the pin concentric with the pocket, and it resists yieldingly to any gravitational or torsional force for a total movement of $^3/_4$ inch. The spring is of unusual form; its turns are progressively eccentric. Thus an end view of the spring would show an inner radius and an outer radius differing from each other by $^3/_8$ inch greater than the thickness of the stock from which the spring is built. Between the outer circumference of the spring and the inner circumference of the pocket is fitted a sheet iron tube, and a similar tube is placed between the spring and the pin. These tubes and the spring form a unit which may be taken intact from the pocket when the outer end cap is removed. On account of their mechanical form and their position in the pockets these springs cannot be stretched beyond their elastic limit, and, since each pocket is provided with adequate lubrication it is expected that they will withstand the most severe wear and last indefinitely. They are capable of sustaining the whole weight of the motor, but they will normally be used solely for transmitting the torque to the drivers. Each pin contains a hollow space in which is placed an additional spring which serves for receiving the end thrust of the motor against the drivers.

The method of carrying the weight of the motor from the truck and of resisting the backward torque of the field structure is by providing a steel frame entirely distinct from the truck and pivoted from the journal boxes of each locomotive axle. From this frame the weight of the motor is carried by springs on which rest lugs of the field structure. The adjustment of the tension on these springs determines what portion of the weight of the motor is carried by them and just how much weight is carried through the pins on the armature quill. Since the frame from which the motor is suspended is distinct from the truck the swinging of the locomotive can have no effect on the motor, and the motor delivers a cushioned blow to the rails. The backward torque of the field is transmitted to the truck through rods which permit a certain amount of vertical motion in the motor. The armature and field windings are of the usual form employed in Westinghouse single-phase series motors. The armature winding is closed in itself and is indirectly connected to the commutator through preventive leads which reduce the short circuit current produced when the brushes pass from one commutator segment to the next. The field winding is of the compensated type with the compensating field evils wound in slots in the projecting pole pieces. These compensating coils are always in series with the armature circuit and serve to neutralize the reactance of the armature.

There are several brushes per holder, and both the brushes and holders resemble closely those used for direct-current work. The brushes are $^3/_8$ inch thick and are pressed against the commutator by a coiled spring. The total locomotive mileage is not yet sufficient to determine the life of the brushes except by approximation from the present rate of wear, and this has been so small that an accurate estimate cannot yet be made. A flexible copper jumper or shunt is used for carrying the current to the brush.

The two armatures on each truck with their corresponding compensating field coils are joined permanently in series and are operated at all times as a unit. For direct-current work the two-motor units of each locomotive are connected in series at starting and in parallel at full speed, while for alternating-current work the two units are joined in parallel at all times. Although during direct-current operation the familiar series-parallel method of control is employed, several unusual features have been introduced so that the losses during acceleration are equally as small as would be the case if there were complete series-paralleling of the four motors by the method used ordinarily with four-motor equipment. The motors being of the compensated type will run sparklessly with the fields weakened to any desired extent, and this condition is taken advantage of during the acceleration period before passing from the series to the parallel position. Thus there is eliminated a large portion of the loss which would take place in the resistance if the motors were changed directly from the normal series position without resistance to the parallel position with the full resistance in circuit. Much of the lower part of the normal speed range in the parallel position is covered by the motors connected in series with shunted field coils.

The acceleration is extremely smooth, which is to be attributed partly to the facts just stated and partly to the fact that in passing from the series to the parallel connection the circuit to neither motor is opened nor is either motor short-circuited. In the initial series position at starting, one motor unit is connected to the ground side and the other to the trolley side, with the resistance in series between them. In the final series position, the resistance is out of circuit and two units are in series across the line. If now there be connected in parallel with each motor unit a resistance of a value such that one-half of the line voltage will cause to flow through it a current equal in value to that passing through each motor, the two motor units will in effect be connected in parallel across the line, each unit having in series with it a resistance which absorbs one-half of the line voltage. Under this condition, no current will flow directly through the middle-voltage connection between the two motor units, and this connection may be broken without changing the performance of the motors, after which the resistance in series with each motor may be decreased until the two units are directly in parallel across the line.

During alternating-current operation, each motor unit is fed at variable voltage from the secondary of a step-down transformer, there being two separate transformers on each locomotive. The same master controllers are used for alternating-current as for direct current.

Each switch used in the motor circuits is of the Westinghouse "unit" type, operated by air under 80 lb. pressure and controlled by an electro-magnet which receives current from a 20-volt storage battery. There are, therefore, on the locomotive three systems of wiring : the 11,000-volt primary circuits to the step-down transformers; the lower-voltage motor circuits (corresponding to the secondary circuits from the transformers and the equivalent 600-volt direct-current circuits), and the battery electro-magnet circuits. The high-potential circuits pass directly from the trolleys through the manually-operated oil switch to one terminal of the primary of each of the step-down transformers, the other terminals of which are grounded to the locomotive frame. The lead from the trolleys to the oil switch is protected by a grounded covering, and only the 20-volt battery runs to the master controller. The motor circuits pass either from direct-current trolley, third-rail shoe or the taps on the secondaries of the transformers to the unit switches and through the motors to the ground.

The unit switches are arranged in groups for convenience, and the switches of each group have their magnetic blow-out coils placed mechanically in the same line so that they assist one another in producing the blow-out flux.

The locomotive may be controlled from either end by means of a master controller which is of the usual type except that its handle is somewhat different from those heretofore used. The handle resembles somewhat the throttle lever of a steam locomotive. No gears are used, the handle being connected directly to the drum shaft. The reverse lever is mounted immediately below the operating lever of the controller. The circuits which run to one master controller, are in multiple with those to the other controller. A continuation of these circuits through flexible leads from one locomotive to another, allows any number of locomotives to be operated simultaneously from one master controller. When the master controller is in the off position, connections are so established that all circuit-breaker trips which may be open may be closed by pressing a small push button on top of the controller. Current is supplied to the control circuits by two sets of 10-cell storage batteries, each of which has a capacity of 40 ampere-hours and weighs 150 lb. In connection with the switch groups, cut-out switches are provided so that either pair of motors may be cut out by simply rendering certain switches inoperative. It is thus possible to cut out the motors without manipulating the main circuit.

There are two pantagraph bow trolleys for collecting the current from the 11,000-volt overhead conductor system. The upward pressure against the wire is supplied by springs. Compressed air is admitted to a cylinder when it is desired to lower the collector. When the collector is in its lowest position, a catch engages the mechanism and holds it in place. This can be released by means of an electro-pneumatically operated lever, when compressed air is on hand, or it can be released manually if desired. The frame-work of the pantagraph mechanism is built up of steel tubing, and the collector bow is a broad strip of soft copper. The collector mechanism is mounted on moulded insulators bolted to the roof of the locomotive.

For use over the New York Central tracks, there have been provided both a second and lower overhead direct-current pantagraph trolley and third-rail contact shoes. The direct-current trolley is of the same general type as that used of the high-potential collectors and it is mounted over te center of the locomotive. There are two mechanically separate but electrically interconnected contact shoes on each side of each truck, making a total of eight shoes per locomotive. These shoes are designed for use with either an over-running or an under-running rail, and the mechanical pressure in each case is supplied by springs. On account of the fact that no third-rail will be used over the high potential portion of the route, and the projecting shoes in their normal position would be liable to strike any small obstruction along the side-paths, a device is used for lifting the contact shoes out of the way when the locomotive in using alternating-current. This device will be operated electro-pneumatically and will be automatic so that when the alternating-current circuit is completed the shoes will be lifted from the rails.

All of the controlling mechanism of the locomotive is placed in the cab In addition to the various switch groups and the two main transformers referred to above, the cab contains two air compressors driven by compensated motors of the same general type as the main driving motors. The circuits to these motors are controlled automatically by the pressure of the air in the main reservoirs which are located underneath the locomotive. The four main traction motors, the high-potential transformers and the main circuit rheostats are cooled by air furnished at low pressure by means of two motor-driven centrifugal blowers which draw air through openings in the cab. The low-pressure air has two paths. One path passes first through the transformer and then to the rheostat. The other path goes directly to the motors. It enters the armature near the shaft, passes around and between the armature laminations, flows outward through the ventilating ducts in the field cores and reaches the outer air through perforated caps on the frame of the motor. Since a considerable volume of air is required for each motor and it is undesirable to cause the air to assume a high velocity, it was necessary to provide a large flexible conduit between the air passages on the cab and those on the motors proper. The flexible conduit is made of heavy canvas tubing which is reinforced with wire and given an accordion pleating. By the use of the air blast the temperature of the motors under load has been so decreased that the continuous rating is almost equal to the one-hour rating.

Cos cob power house.

The initial single phase electrification comprises that portion of the New York division of the New York, New Haven & Hartford from Stamford, Conn., to the junction with the New York Central at Woodlawn, N. Y., 21 miles. From Woodlawn to the Grand Central Station, the New Haven trains are operated over the tracks of the Harlem division of the New York Central by the New Haven electric locomotives, using direct current from the New York Central's third rail electric equipment. The power house at Cos Cob furnishes single-phase current for the operation of electric trains over the New Haven road, and is also designed to deliver three-phase current to the Port Morris power house of the New York Central to compensate for the energy required to operate the New Haven trains over the lines of the New York Central.

The power house is adjacent to the main line of the railroad and on the bank of the Mianus river about one mile from Long Island sound. Coal can be delivered either by water or rail, and an unlimited amount of salt water for condensing purposes is available. By the erection of a dam in the river, about a mile up-stream from the power house, an abundant supply of pure boiler feed-water is obtained.

The general style of architecture of the power house building is Spanish Mission; the walls are built of plain-faced concrete blocks. The site selected was on solid rock, and this required blasting the excavation for the basement and the condenser intake and discharge flumes. The building walls, below the water-table, and the machinery foundations are monolithic concrete. The interior columns in the boiler room are of structural steel, but all other columns required in the building are of concrete blocks. The steel roof trusses over the turbine room are supported on concrete block pilasters formed in the building walls, while over the boiler room they are carried by the pilastered building walls and by the interior steel columns, which also support the boilers, the mechanical draft equipment and the stack. The front of the switchboard gallery, at the south end of the turbine room, is carried on concrete block columns which also support a reinforced concrete girder forming one of the crane runways. The other crane runway is formed by another reinforced concrete girder built into the partition wall between the engine room and boiler room, and is supported on pilasters formed in this wall. The basement floor is concrete, laid on the rock. All other floors in the building are of reinforced concrete; and the roof is of reinforced cinder concrete finished with Ludowici tile.

A self-supporting steel stack 13 ft. 6 in. in diameter extending to a height of 100 feet from the engine room floor, is carried by the steel columns which support the fan room floor, leaving the space below, on the boiler room floor, entirely clear.

The turbine room is 60 feet wide by 112 feet long, and the switchboard occupies a space next the turbine room which is 25 feet wide by 110 feet long. The boiler room is 160 feet long and 110 feet wide.

The initial generating equipment of the power house consists of three multiple expansion parallel flow Parsons steam turbines direct-connected to single-phase Westinghouse generators. Provision has been made for the installation of a fourth unit of corresponding size. The turbines are rated at 4,500 brake horse-power each and the generators of 3,000 kilowatts each, at 80 per cent power factor.

As the requirements necessitated the generation of three-phase current for delivery to the New

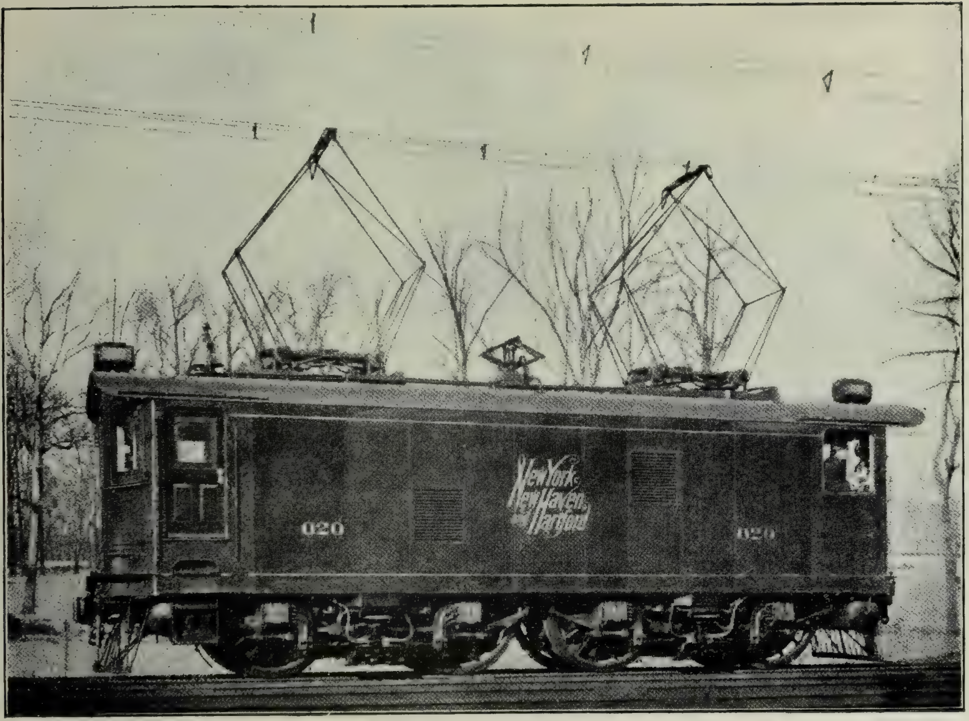

Fig. 7. — New Haven electric locomotive with A. C trolleys raised.

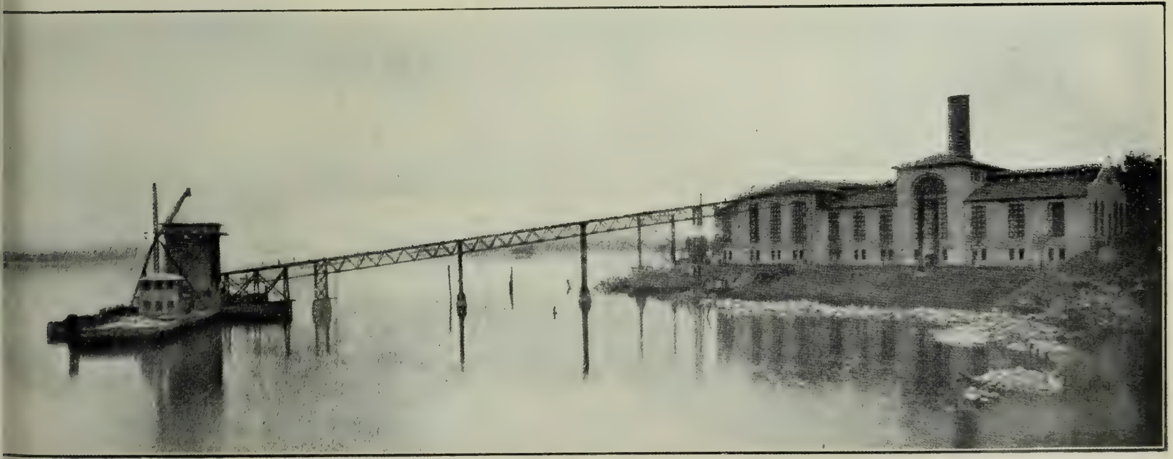

Fig. 8. — Cos Cob power house and coal dock; New York, New Haven & Hartford.

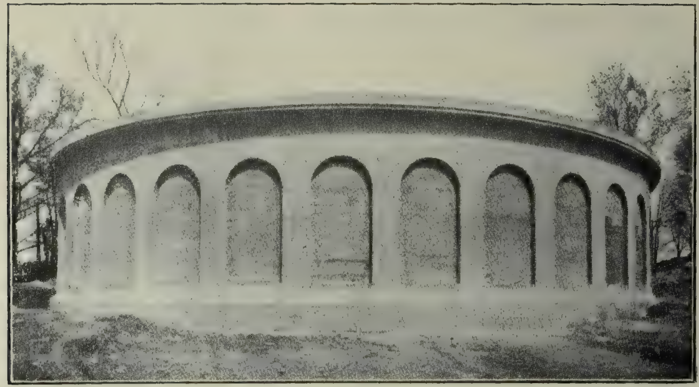

Fig. 9. — Concrete water reservoir at Cos Cob power house.

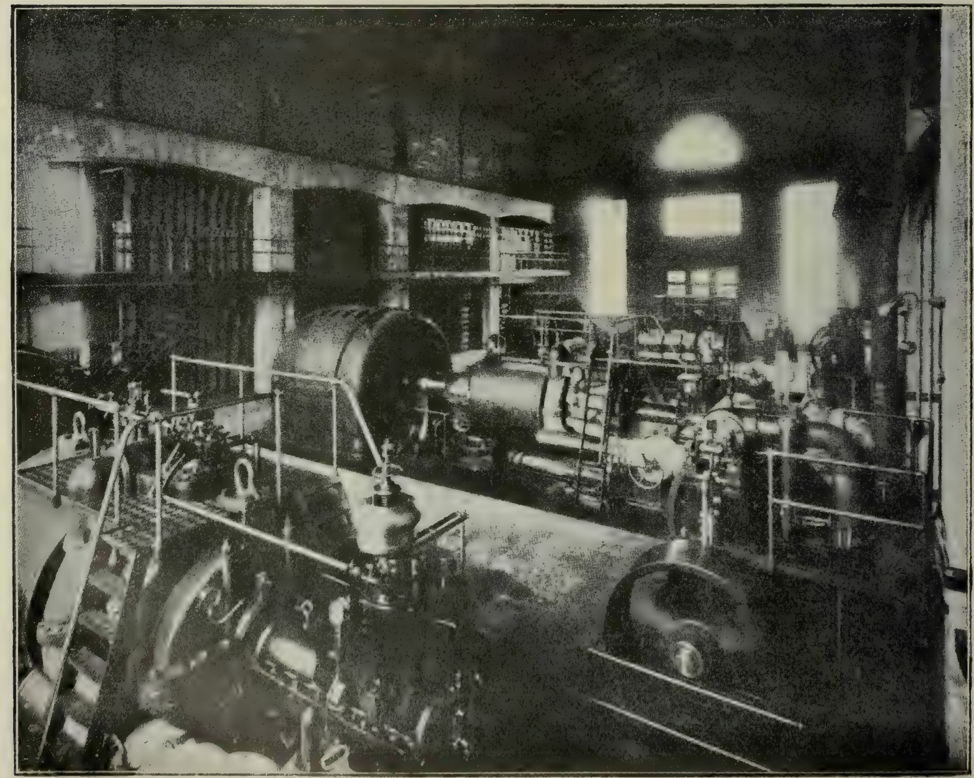

Fig. 10. — Interior of turbine room at Cos Cob power house.

York Central system as well as single-phase current for the operation of the electric locomotives over the New Haven railroad, the generators are wound for three-phase current but are arranged for the delivery of both three-phase and single-phase current. The turbines are operated at 1,500 revolutions per minute by steam at 200 lb. pressure and 100° superheat. The continuous overload capacity of the units is 50 per cent, and momentary overloads of 100 per cent can be taken care of when operating condensing.

The generators are entirely enclosed by a casing into which air is drawn through suitable ducts from a fresh air chamber under the switchboard gallery, and from which the air is discharged through other ducts into the basement. This renders the operation of the generators practically noiseless.

The excitation of the generator fields is provided for by two 125-kilowatt direct-current generators, direct-connected to Westinghouse engines; and one motor-driven exciter.

To prevent rapid deterioration of the brass condenser tubes by galvanic action, a motor generator set has been installed and provided with suitable controlling apparatus for maintaining in each condenser a counter electro-motive force slightly in excess of the electromotive force due to galvanic action and the stray currents.

The initial installation of boilers consists of twelve 525-horse-power Babcock & Wilcox water-tube boilers set in batteries of two boilers each, and arranged with eight boilers on one side and four boilers on the other side of the boiler room separated by a 21-foot firing floor. Provision is made for four additional boilers to take care of the fourth turbo-generator unit when installed. These boilers are equipped with Roney mechanical stokers and Babcock & Wilcox superheaters and deliver steam at 200 lb. gage pressure and 125° superheat.

Under ordinary conditions, the boiler feed water is delivered from the pump house at Mianus through a 10-inch main to a concrete reservoir of 600,000 gallons capacity just outside the power house. From this reservoir the water flows by gravity to two 13,000 gallons feed water tanks in the boiler room basement. These tanks also receive the discharge from the hot well pumps. The water is then drawn from these thanks by the feed pumps and delivered through the feed water heaters and the economizers into the boilers.

An auxiliary source of feed water supply is provided for by a connection to the mains of the Greenwich Water Company.

Four 14-foot fans, direct-connected to horizontal high-speed engines, deliver the flue gases from the economizers to the stack, which is only of sufficient height to carry the gases away from the building.

All coal received by water is unloaded from barges by a steel derrick operating a clam shell bucket and delivering to a hopper of 15 tons capacity at a height of 55 feet above the dock. From this hopper the coal is fed by gravity into a coal crusher and from the crusher it drops into steel cars where it is weighed. The cars are then drawn by cable up an inclined railroad into the boiler room through an opening near the roof. Two cars can be operated on this track, passing each other through an automatic turnout at the center. The cars discharge the coal into a hopper, from which it is delivered into two flight conveyors, extending the length of the boiler room. Openings in the bottom of the flight conveyors discharge the coal into spouts leading to the stoker hoppers of the boilers. The capacity of the flight conveyors is in excess of the amount of coal required to operate the boilers, and the surplus coal is discharged at the further end of the boiler room into a concrete storage bin below the boiler room floor. Coal received by rail is dumped from the car directly into a chute leading to this storage bin. When the boilers are to be supplied from this source the coal is discharged from the bin by gravity into a coal crusher, thence into a bucket conveyor located in a tunnel underneath the bin, by which it is delivered to the flight conveyors above the boilers, and thence through the chutes to the stoker hoppers. The cable railway and the conveyors are operated by three-phase induction motors, taking current from the station service line.

The ashes are disposed of by gravity from the dumping grates of the stokers into chutes leading to narrow-gage cars in the basement, by which they are at present carried to the low ground in the neighborhood of the power house and used for filling.

The Westinghouse Electric & Manufacturing Company were the contractors for the electric locomotives, catenary track equipment and turbo-generator units. Westinghouse, Church, Kerr & Co. were the contractors for the Cos Cob power house and equipment. The task of determining and analyzing operating conditions and requirements was assigned to Calvert Townley, consulting engineer, and William S. Murray, electrical engineer, of the New Haven Company, to whom credit is due for the design, supervision and execution of the details.

[656 .256]

ELECTRIC INTERLOCKING OR MECHANICAL INTERLOCKING

BETWEEN THE BLOCK APPARATUS AND THE SIGNALS,

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(*Organ für die Fortschritte des Eisenbahnwesens.*)

Mr. Boda has described (¹) a system of control in which the interlocking between the block sections of the block apparatus and the signals is effected by electric means only, by electric connections to the signal arms and the action of the train on the current flowing through these connections. This system enables the expensive locking frames and locking bars and treadles to be dispensed with, and, so long as no train has actually left the block section, the opening of the next section can be cancelled without breaking the seals on the block apparatus or allowing a train to pass a signal at danger (²).

The method of effecting the interlocking was described by me in 1895 and patented by Messr. Siemens & Halske (³). Since then, this apparatus has been fixed in all the electrically operated cabins under the most diverse conditions; the apparatus has worked well in every respect. With mechanical operation the system was first used in Baden (⁴).

Now although the use of electric interlocking gear involves no difficulty with the electric operating gear, in connection with which it was first designed, and although, in this case, it is clearly advantageous to employ it, yet it is not possible to affirm positively, without further consideration, whether electric interlocking is to be generally recommended also for frames operated by manual labour.

The safety ensured by electric connections to the signal arms depends on the three following factors : the supply of current, the proper adjustment of the signal wires, and the efficiency of the contact of the rail or electric treadle of the block section.

With a central electric operating gear, in order that the working may be conti-

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(¹) *Organ*, 1906, p. 89.

(²) By flag for instance. (*Translator's note.*)

(³) German patent No. 88611.

(⁴) *Zeitung des Vereines Deutscher Eisenbahn-Verwaltungen*, 1903, p. 105.

nuous, the supply of current must not be interrupted, and the installation must be sot arranged, without considering the question of expense, that the supply of curren cannot fail under any circumstances. This condition is satisfied, in the case of manual frames, in the largest stations only. In others, accidental interruptions of the supply, of however short duration, have to be expected occasionally. During a period of interruption the mechanical connections to the signal arms would require to be disconnected, and with the proposed electric interlocking all precautions for safe working would fail. The same would occur if the length of the signal wires were not properly adjusted; in this case also, the lever would need to be disconnected for some time.

In the case of electrically operated signals, these two difficulties are not to be feared; the connections to the signal arms are fitted so that there is no provision for disconnecting them, whereas this is absolutely essential in the case of mechanically operated signals.

Finally, the disconnection of the signal connections by the train itself (automatic return to danger position), where the Siemens mercury contact is used, especially with its latest improvements, is at least as reliable as the locking bars and bolts of the mechanically operated levers. Perhaps the electric system is even safer, since any failure whatsoever makes itself immediately apparent, by preventing the block from being cleared, whereas in the case of ordinary mechanical interlocking, a defect in the working may pass unperceived, until the apparatus undergoes its next examination or an accident occurs.

Further, as regards the safe working of the unlocking, the central electrical operating gear has the advantage of a more regular supply of current.

We have mentioned a recent improvement (¹) of the Siemens mercury contact or electric treadle. It consists in passing the connecting current through the treadle, and the circuit is only completed when the level of the mercury is raised to a certain height. It follows that, if by any means there has been loss of some of the mercury, the connecting current cannot pass and no signal can be operated. If the mercury is too high, the block apparatus or the electromagnetic switch would remain permanently excited and the connecting circuit would be held open. It is therefore necessary that the mercury should have exactly the desired height, or else no signal can be operated. Now this can only be the case when all is in perfect order, and then the electric treadle will work properly. Risk of fracture of parts and disturbing influences which might prevent the contacts from working properly in any other form of construction are not to be feared in the case of the mercury contact for the simple reason that there are no moving parts.

If, by chance, the locking magnet failed to unlock, while the treadle worked properly, the connecting circuit would be open at the contact and in this case also the signal would return to danger.

The conclusion we draw is that the use of the Siemens electric gear, interlocking the track apparatus and the operating levers, with the elimination of locking bars and bolts on the levers, can be recommended unreservedly where the signals are

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(¹) Patent applied for.

electrically operated, whereas in the case of mechanically operated frames, it can only be recommended when the circumstances are so particularly favourable both as to supply of current and adjustment of the signal wires, that it is possible to dispense with an arrangement for throwing the connections out of gear.

This conclusion has been accepted in current practice. Whereas all the electrically controlled frames are fitted with electric interlocking, the electric interlocking is but rarely used for mechanically operated frames.

MISCELLANEOUS INFORMATION

[656 .212.5]

1. — The new shunting yard at Mannheim.

Fig. 1, p. 1177.

(*Zeitung des Vereins.*)

On May 1 of this year, the whole of the new shunting yard at Mannheim was thrown open to traffic; on October 1 of last year, the greater part of the shunting operations had been transferred from the old yard to the south part of the new yard, so that during the winter 1906-1907 the north half of the old shunting yard and the south half of the new were utilized simultaneously. The new yard is going to be used as a joint yard for the Prusso-Hessian and Baden State railways. It is located to the east of the old shunting yard and is parallel to the Mannheim-Heidelberg main line; it extends to the east, past Seckenheim station to near Friedrichsfeld station. The total length is about 5 kilometres (3 miles).

In accordance with the importance and the direction of the traffic that has to be dealt with, the yard is divided into two parts, arranged according to direction and each with sets of gravity sidings. Each part has a set of sidings for arriving trains and a set for departing trains, and a larger set for sorting operations. There are three smaller sets of sidings on which, if necessary, wagons sorted according to direction can be sorted according to station.

These two parts (north part and south part) are of approximately equal size; between them (from west to east) are interposed : 1° the disinfecting establishment; 2° the locomotive sheds, for 60 locomotives, with two large turntables; 3° the carriage repairing shops together with the necessary sidings; 4° the chief goods offices; 5° two tranship sheds, together with the appliances and sidings required. The chief offices together with the staff quarters are to the south-west of the yard. Next to this, and also next to Seckenheim station and next to the chief goods offices, special buildings and sleeping quarters have been erected for the accommodation of the train crews and of the station staff. Two bridges, about 2 kilometres (1·2 miles) apart, go right across the shunting station; the highway is carried on these bridges so that the north-south road traffic is not interfered with. The approach to the station is by stairs from the bridges.

Goods trains from the following lines enter this shunting yard :

a) From the west : 1° the trains from the different parts of the chief goods station and from the docks; 2° the trains from the Palatinate, *viâ* Ludwigshafen; 3° the trains from the docks of Rheinau and Neckarau; 4° the Riedbahn trains (from Frankfort and Mayence); 5° the trains from the local docks ;

b) From the east : 1° the main line trains from Karlsruhe and some trains from Bretten

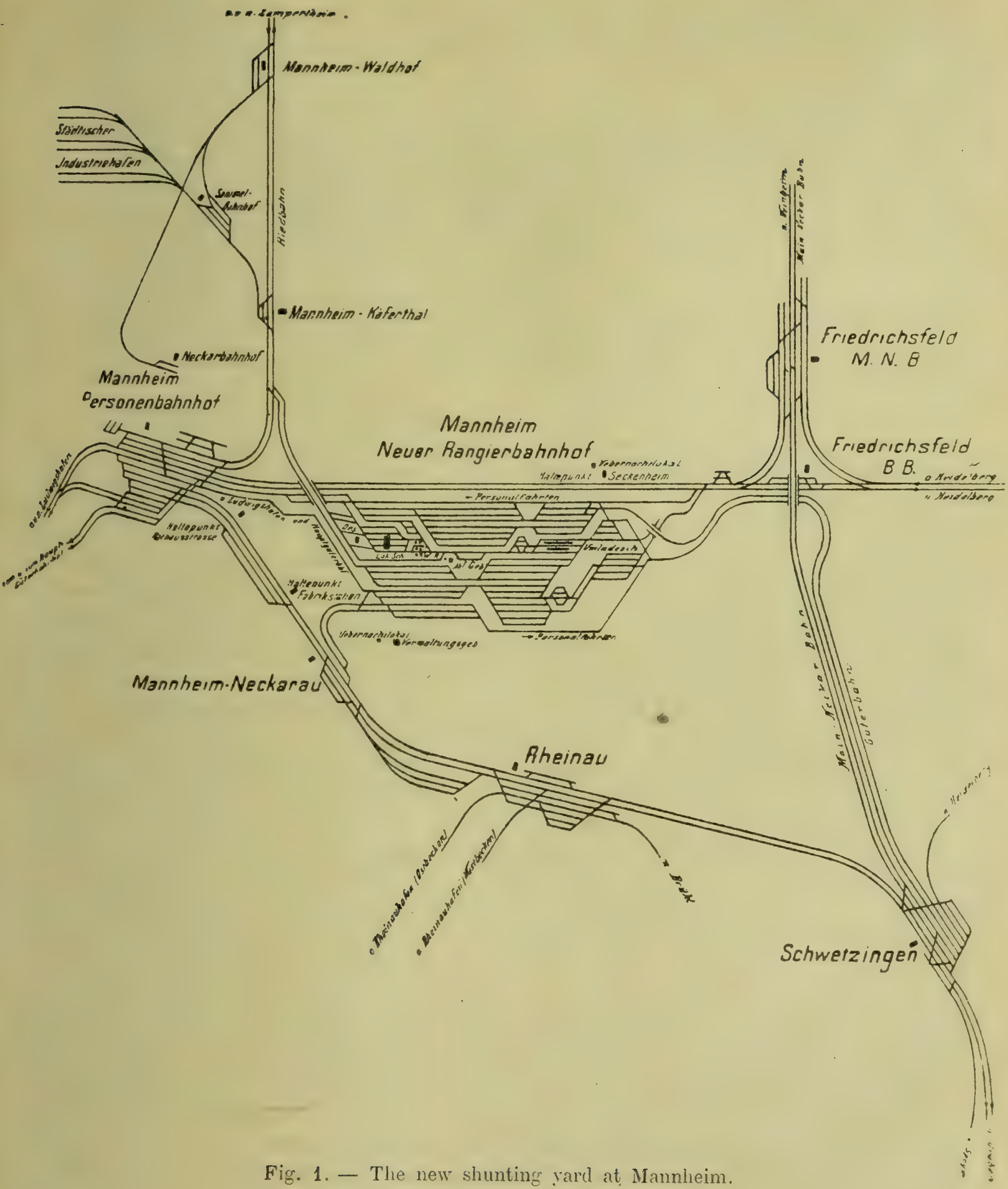


Fig. 1. — The new shunting yard at Mannheim.

Explanation of German terms: Haltepunkt = Stopping point. — Hauptgüterbahnhof = Chief goods station. — Neuer Rangierbahnhof = New shunting yard. — Personalfahrten = Service track. — Personenbahnhof = Passenger station. — Rheinauhafen Ost becken = Rheinauhafen, east dock. — Rheinauhafen West becken = Rheinauhafen, west dock. — Sammelbahnhof = Collection sidings. — Städtischer Industriehafen = Local town docks. — Uebernachtlokal = Sleeping quarters. — Umladesch. = Tranship sheds. — erwaltungsgeb. = Head office.

viâ Heidelberg; 2° the trains of the Odenwaldbahn and of the Heilbronn line; 3° the trains of the Main-Neckarbahn; 4° the trains coming from Karlsruhe and Bretten *viâ* Schwetzingen (Rheintalbahn).

The Riedbahn goods line branches off the main line near the Neckar bridge and continues, crossing above the Mannheim-Heidelberg main line, to the new shunting yard. A double-track line has been provided, between Schwetzingen and the new shunting yard, for goods to or from Schwetzingen (Rheintalbahn); this line runs parallel to the Main-Neckarbahn. A double-track junction line, between the new shunting yard and Friedrichsfeld station, has been constructed for the trains to and from the Main-Neckarbahn. 121 regular trains arrive every twenty-four hours at the yard; 74 arrive at the west and 47 at the east end of the yard. 125 trains leave the yard, so that the sum of the arriving and departing trains is 246, and 10 trains have to be taken apart or put together every hour on the average. In addition, there are the optional trains; up to 15 arrive and up to 15 leave.

The goods trains from the west are taken apart on the south grid, consisting of thirty tracks, and those from the east on the north grid, consisting of twenty-one tracks. Consequently, leaving optional trains out of consideration, 2 trains per hour must be dealt with on the north grid, and 3 trains per hour on the south grid; thus thirty and twenty minutes are available for each train respectively. But as evidently the trains cannot arrive at regular intervals (for instance, between 6 and 11 p. m., the south grid receives 24 trains, *i. e.* nearly 5 per hour), at times a train must be dealt with in from twelve to fifteen minutes, or else a block will ensue.

Generally speaking, the wagons coming from the east to the north part of the yard are for trains leaving the west of this part, whereas the bulk of the wagons coming from the west to the south part of the yard are for trains leaving the east of that part of the yard. Thus in the north part the direction of most of the traffic is from east to west, and in the south part, from west to east. The transfer of wagons arriving in one part of the yard and intended for trains leaving the other part af the yard, and the transfer of the parcels vans to the tranship sheds, is effected by special shunting operations, which are carried out once every hour. From May 1 onwards, including the traffic to and from the Main-Neckarbahn and the Odenwaldbahn *viâ* Schwetzingen and Heidelberg, the new Mannheim shunting yard has received every day 5,000 wagons; so if we assume that in addition to the 121 regular trains, 5 optional trains arrive on the average per day, then the average train consists of 40 wagons. But as of the 121 trains about 20 per cent are for parcels and local traffic, and consist of only 20 to 30 cars, the other trains consist on the average of 45 wagons. Owing to the concentration of the traffic and the possibility of collecting more wagons going in the same direction than formerly, the formation of new long-distance goods trains is materially facilitated. In addition to such trains to Bale and Singen (Switzerland), with sections to Schaffhausen and Constance, some are also made up to go *viâ* the Baden-Wurtemburg station Bretten to Ulm and Stuttgart, and some also to Bebra and Cologne; altogether 23 such long-distance goods trains are despatched every day. Moreover, by properly fitting together the times of the long-distance trains from Cologne and Bebra and of those to Bale, Singen and Ulm, and *vice versa*, a material acceleration of the long-distance through traffic was obtained. It is also expected that by properly fitting together the times of the long-distance goods trains running between Bebra and Mannheim on the one hand, and between Bebra and Hamburg, Bremen and Berlin on the other, it will be possible to improve the connections between North and South Germany.

The two tranship sheds in the east of the yard, mentioned in the beginning of this article, have been in use since May 1 for the tranship service of Mannheim and Heidelberg stations; it is expected that every day 230 wagons will be despatched and 290 will arrive, so that a total of 520 wagons will be dealt with.

The train crews and the station staff are carried to and from the goods trains and the different parts of the yard by 48 service trains, simply equipped, one going in each direction per hour, between the end of the shunting yard and Mannheim passenger station. These trains run, as shown in the figure 1, on the track furthest north and on the track furthest south; the westward bound trains on the former and the eastward bound on the latter.

[621 .132.5]

2. — Erie Mallet compound locomotives.

Figs. 2 to 7, pp. 1180 to 1182.

(*Railway and Engineering Review.*)

It was only three years ago that the railroad world was astounded by the enormous weight of the first example of the articulated compound in this country, the Mallet articulated compound built for the Baltimore & Ohio Railroad by the American Locomotive Company. Although at the time this engine was looked upon as freakish, it has been entirely successful both from the standpoint of operation and maintenance. The success of this engine has demonstrated the advantages offered by this type for the construction of very heavy units, and has brought about the increasing popularity of the type which has reached its highest development in the engines here illustrated. Although these Erie engines are much heavier and more powerful than the Baltimore & Ohio engine, the essential features of the two designs, such as flexible joints to high and low-pressure cylinders, receive and exhaust pipes, articulated connection between frames, boiler, bearings, power reversing gear, etc., are practically the same, none of these features having failed to give perfect satisfaction during the two years this engine has been in continuous service.

The accompanying tabular comparison will show the principal differences in the two designs.

It must be noticed in compariing the above ratios, that the engine illustrated is provided with a 4-foot combustion chamber, which decreases the total actual amount of heating surface. On account of the greatly increased weight it was necessary in this design to introduce another pair of driving wheels into each group.

Like the Baltimore & Ohio engines, these engines are designed for pusher service. They will operate between Susquehanna and Gulf Summit, where the ruling grade is 1·3 per cent. In working order, they have a total weight of 409,000 pounds, all of which is on the driving wheels — there being eight coupled wheels in each group. Considering the fact that the average load per axle of 50, 25 pounds, is less than that of many road engines of the present day, the advantage of this type for obtaining a maximum adhesion for tractive power with a minimum rail pressure per wheel, is clearly shown. The boiler, which is shown in the accompanying illustrations, is the largest locomotive boiler ever built. It is of the radial stayed type with conical connection, the inside diameter of the first or smallest course being 82 inches, while the inside diameter of the largest course is 96 inches. The heaviest ring of the shell is 1 $^{5}/_{16}$ inches thick. The water alone in the boiler weighs 42,700 lb., and the tubes, of which there are 404 in number, 2 $^{1}/_{4}$ inches outside diameter and 21 feet long, weigh 23,700 lb. The total weight of the boiler with water is 139,900 lb. The fire-box is of the Wooten type, 120 1/8 inches long and 114 1/4 inches wide, and has a grate area of 100 square feet. The water space at the mud ring is 5 inches on all sides.

Road.	Baltimore & Ohio.	Erie.
Wheels	0660	0880
Total weight	334,500 lb.	...
Size of cylinders	20 and 32 × 32 in.	25 and 39 × 28 in.
Diameter of drivers	56 inches.	51 inches.
Tractive effort (working compound)	71,500 lb.	94,800 lb.
Steam pressure	235 lb.	215 lb.
Total wheel base	30 ft. 8 in.	39 ft. 2 in.
Driving-wheel base, rigid	10 feet.	14 ft. 3 in.
Total heating surface	5,600 sq. ft.	5,313·7 sq. ft.
Grate area	72·2	100
Weight on drivers ÷ Tractive effort	4·78	...
Total weight ÷ Total heating surface	599	...
Tractive effort × diameter drivers ÷ Total heating surface	700	910
Heating surface ÷ Vol. equiv. simple cylinders	295	217
Grate area ÷ Vol. equiv. simple cylinder	385	408

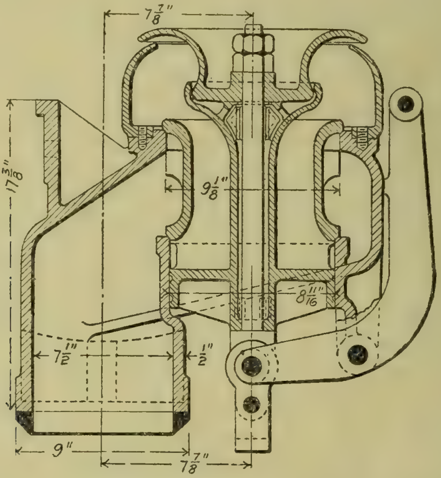


Fig. 7. — Steam drying throttle of Erie locomotive.

The dome, which is of cast steel, has been placed on the top of the conical course. The throttle, which is clearly shown in one of the accompanying illustrations, acts also as a steam dryer. Steam is admitted through the top only, and the water entrained strikes against the walls of the special shaped casting covering the top of the throttle pipe, and as is the tendency of water under pressure, follows the surface of this casting, and passes down through the center of the valve instead of going in to the dry pipe. Steam is led from the throttle pipe through a short dry pipe to a point directly in line with the high-pressure cylinders, from whence it passes through the top of the shell and is divided into a tee-pipe and passes down through wrought-iron steam pipes on either side of the boiler to each of the high-pressure valve chambers. The design of the high-

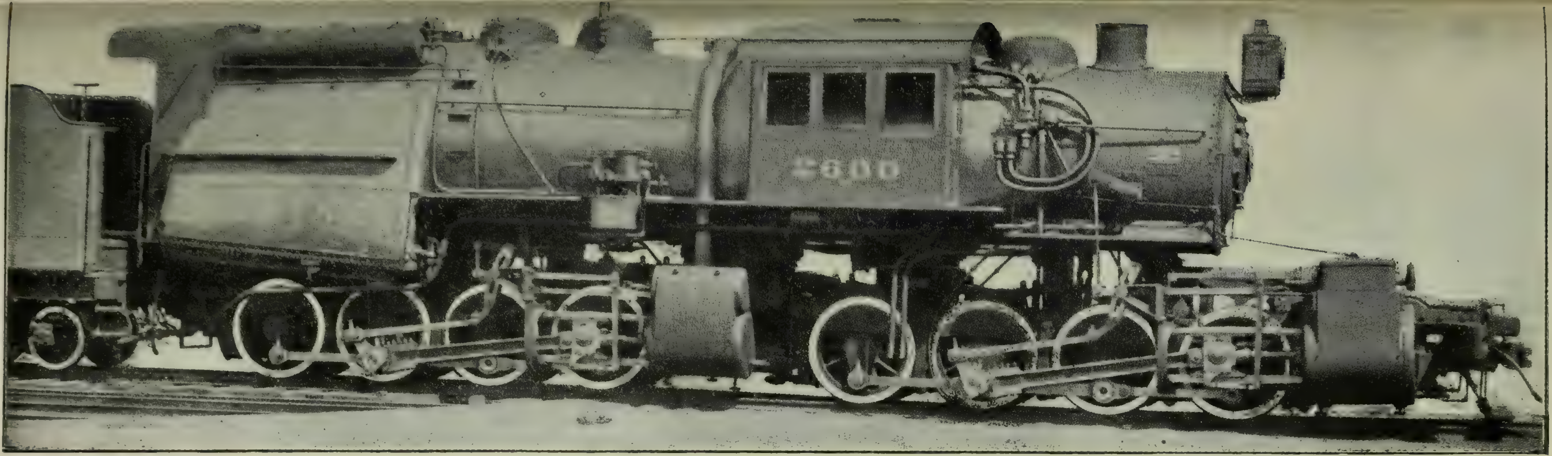


Fig. 2 — 410,000-lb. locomotive for Erie Railroad. — General appearance.

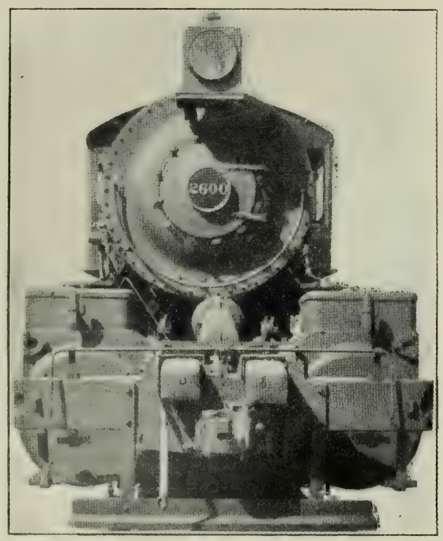


Fig. 3. — Front view of Erie locomotive.

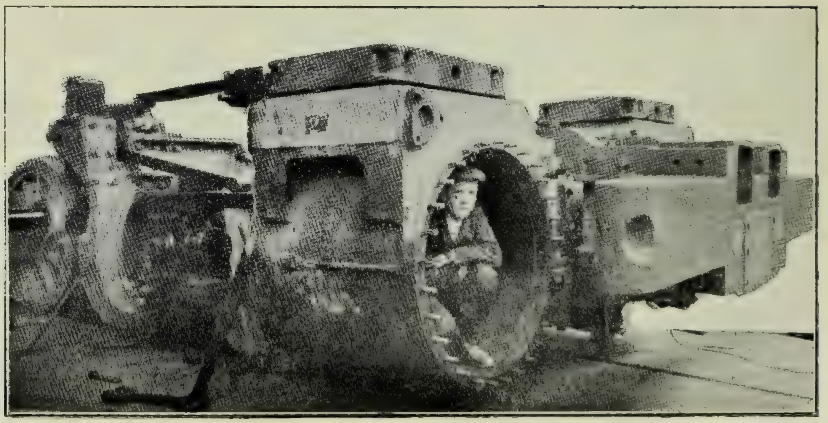


Fig. 4. — Low pressure cylinder of Erie locomotive.

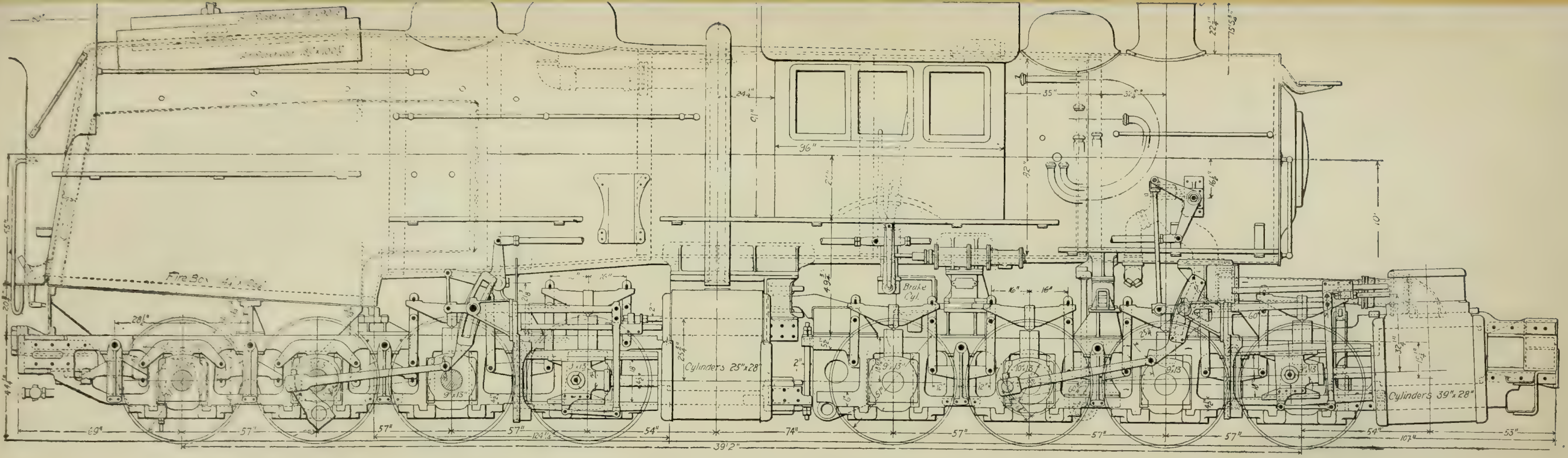
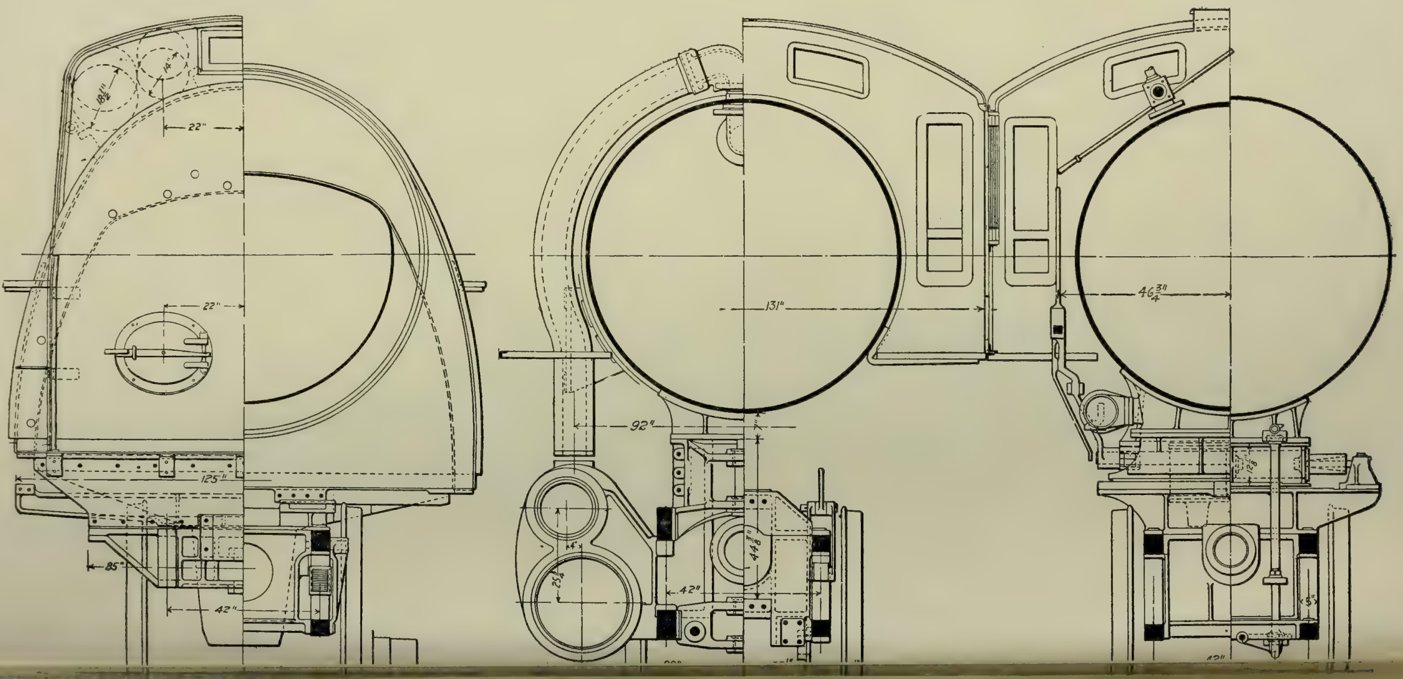


Fig. 5. — General design of 410,000-lb. Erie Railroad 0-8-8-0 locomotive.



pressure cylinders is similar to that used on the Baltimore & Ohio engines, the cylinders being cast in pairs with saddles, and the separation between the two cylinders being 8 ½ inches to the right of the center line of the saddle, to make room for the receive pipe.

The engines are compounded on the Mellin system, the intercepting valve being located in the upper part of the left cylinder casting. Exhaust steam from the right high-pressure cylinder passes through a cored passage to the back of the cylinder casting, from whence it passes through an outside U-shaped pipe connecting to a passage in the left cylinder casting leading up into the intercepting valve chamber, into which the exhaust steam from the left high-pressure cylinder also passes. The emergency exhaust valve is located in the side of the left cylinder casting and has a 4 ½-inch jointed pipe connection, with an opening in the back of the exhaust pipe in the smoke-box. A three-way cock within easy reach of the engineer, operates the emergency exhaust valve.

Steam from the high-pressure cylinders passes into a 9-inch receiver pipe extending forward from the center of the cylinder saddle, to which it is connected by means of a ball joint. In order to facilitate putting in place or removing this pipe is made of three sections, and is connected at the front end by means of a slip joint to cover variations in length due to curving to a Y pipe through which steam reaches each of the low-pressure steam chests. The receiver pipe is laid out for 16-degree curves. The flexible connections are the same as those used in the Baltimore & Ohio design, which have proved so satisfactory, no trouble from leaky joints having been experienced throughout the entire two years this engine has been in service. Steam from the low-pressure cylinders, which are located considerably ahead of the front end of the boiler, exhausts back through a flexible pipe connection to the exhaust pipe in the smoke-box.

The high-pressure cylinders are equipped with piston valves, and the low-pressure cylinders with Richardson slide valves. The valve gear is, of course, of the Walschaerts type. By an ingenious arrangement of the reversing gear, the weights of the valve motions of the front and rear engines counterbalance each other. The general elevation clearly shows the arrangement. As the high-pressure valves are internal admission and the low pressure external admission, it was possible with this arrangement of reversing gear to obtain a most satisfactory valve motion with both eccentric cranks leading the pin, the rear engine taking the forward motion from the top of the link, and the front engine from the bottom of the link. The operation of the engine is rendered easier than that of an ordinary road engine by the application of pneumatic reversing cylinders to the ordinary gear, with positive automatic locking in any desired position. The frames of both the front and rear engines are of cast steel 5 inches wide.

The part of the weight of the boiler which is carried on the forward engines, is supported by a self-adjusting sliding bearing located between the third and fourth driving wheels. This bearing consists briefly of a built-up saddle casting which extends down and bears on a cast steel cross-tie directly below it, through a wrought-iron, case-hardened sliding plate. A brass wearing plate is introduced between the boiler bearing casting and the wrought-iron plate. The sliding plate is radially planed on the bottom, so that it adjusts itself to the alignment of the engine, and the load on the sliding plate is at all times perfectly distributed, and there is no cutting of the wearing surfaces. Movement in a vertical direction is prevented by a safety connection between the boiler bearing casting and the cross-tie, which prevents the frames from dropping away from the boiler in case of any derailment. There is also a similar safety connection provided at the front end of the boiler between the guide yoke casting and the exhaust pipe elbow.

Another sliding support is located between the second and third pair of driving wheels. This support is so adjusted that it does not take any of the load except under unusual conditions, whe inequalities in the roadbed make it necessary. It is provided with a floating balance device which serves to take some of the load off the main boiler bearing. This device consists of a pair of columns, one on either side of the center of the engine, free to sway as the engine turns through curves. These columns have a ball joint connection at the upper ends with saddle castings bolted to the boiler, and a ball joint connection at the lower ends with flap castings hinged to the bottom of a cross-tie across the lower rails of the frame. Around the outer ends of these hinged castings are U-bolts, the horns of which extend up through the bottom of the cross-tie and through coil springs seated on the cross-tie. These springs thus exert an upward force on the columns equal to the total compression of the springs. The initial total compression is 30,000 lb., which can be increased by screwing down the spring caps by means of nuts on the ends of the U-bolts. This boiler support is also provided with a spring centering device of the same design as that used on the Baltimore & Ohio engine.

Another sliding support is formed between the exhaust pipe elbow and the guide yoke casting. As mentioned above, this support also forms a connection between the boiler and the frames.

The four pair of front driving wheels are equalized together on each side and cross-equalized in front of the forward drivers, making this system equivalent to a single supporting point. The rear engine, on the other hand, is equalized throughout on each side only without cross-equalization. This forms a complete three-point suspended engine or the best obtainable condition for flexibility and ease on the track.

[625 .616]

3. — Locomotives for Matheran Railway.

Figs. 8 to 11, p. 1185.

(*Railway and Locomotive Engineering.*)

The Matheran Railway in India is a small line of 2 feet gauge constructed up the hillside of a pleasure resort in the near vicinity of the city of Bombay. The railway has a total length of 12 miles, and starts from Neral Station, on the Great Indian Peninsula Railway, 132 feet above the sea level, and rises to the Matheran terminus, 2,495 feet. The maximum grade is 1 in 20, and to work the trains over this line, some small tank engines have been supplied by Messrs. Orenstein & Koppel, which are of novel construction. They have six coupled drivers 30 inches in diameter, which are not connected direct to the axles in the usual way, but are mounted on hollow cylinders or sleeves, through which the driving axles pass, the motion being communicated through ball joints at the centre. The larger of our line illustrations shows the complete arrangement of one of these engines, while the other represents the details of the driving gear and hollow or sleeve axles.

These little engines, when delivered in India, were fitted with the " counter-pressure " retarding device. This brake apparatus, known as the Riggenbach system, is so designed that when the engine is running down grade with the valve gear reversed and the blast pipe closed air is drawn into the cylinders through the cylinder cocks and pumped into the steam pipe, and so acts as a retarding agent. The pressure is regulated by means of a valve in the cab under the control of the engineer, who can supply water from the tanks to the cylinders to cool them when necessary. This arrangement, we understand, did not work satisfactorily, and has since been replaced by the automatic vacuum brake.

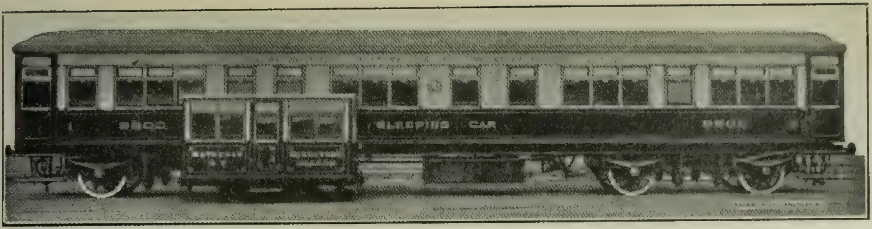


Fig. 8. — Main line and Matheran branch coaches.

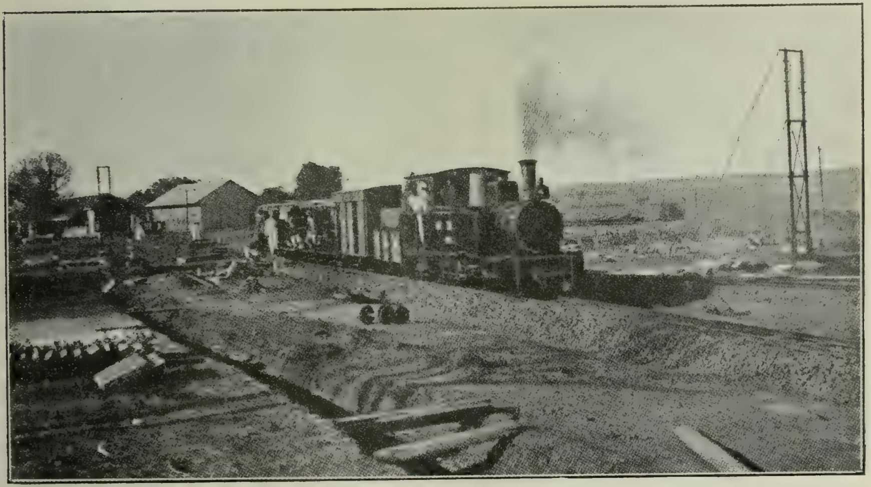


Fig. 9. — Engine on the Matheran Railway leaving Neral at foot of incline.

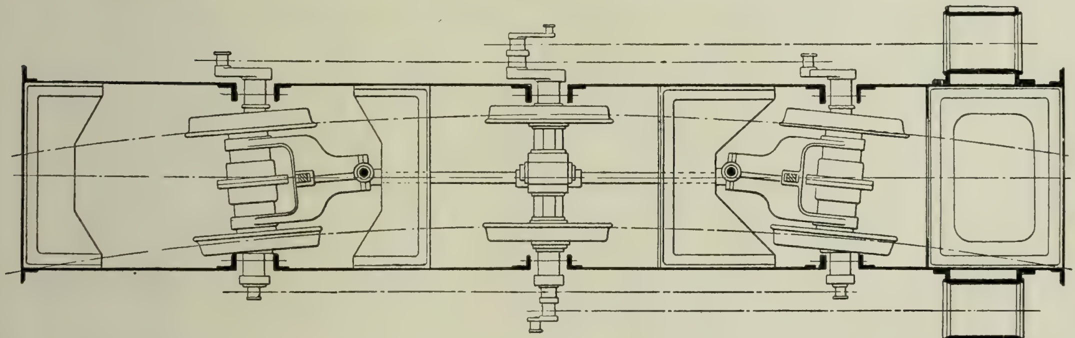


Fig. 10. — Plan of Matheran Railway engine, showing solid axles with crank pins, and hollow sleeve between wheels. Rods remain parallel wheels follow curves.

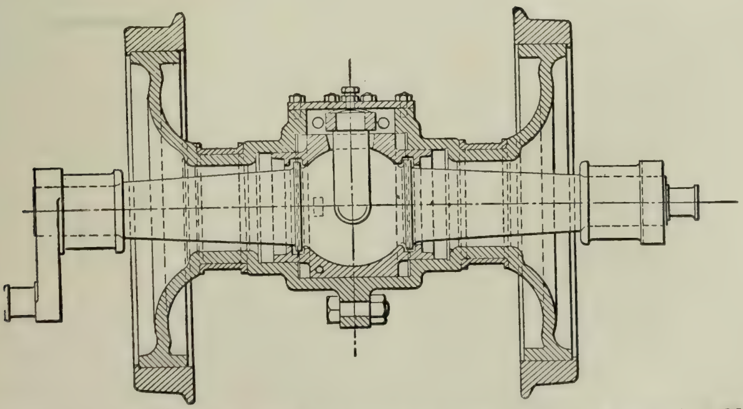


Fig. 11. — Wheels with hollow sleeve containing solid axle with central ball joints for driving; Matheran Railway.

The side tanks have a capacity of 450 imperial gallons for water, but this is not sufficient for the present system of working, and is supplemented by a small tender. The total weight of the engine in working order is 39,000 lb.

A few of the principal dimensions are as follows :

Cylinders : diameter, 11 $^{15}/_{16}$ inches; stroke, 13 $^{15}/_{16}$ inches. Boiler : length of barrel, 7 ft. 10 $^{1}/_{2}$ in.; diameter, 3 ft. 2 in. Heating surface, 452 square feet; grate area of fire box, 7 square feet; working pressure, 175 lb. per square inch.

[621 .335]

4. — Metropolitan Railway electric locomotives for passengers and goods service.

Figs. 12 to 15, pp. 1189 and 1190.

(*The Railway Gazette.*)

Of the ten electric locomotives for passenger and goods service which are being supplied by the British Thomson-Houston Company Limited, of Rugby, to the Metropolitan Railway, three have been delivered up to date.

These locomotives are of the double bogie type with box-wagon shaped cab, and weigh, in running order, 47 tons. The motors with which they are equipped are of the G. E. 69 type with one-turn armatures, the gear ratio being 64/19 = 3·36, one motor being mounted on each of the four axles. They are of 200-horse power each, and weigh, complete with gearing and gear case, approximately 6,100 lb. They are of the box frame type with nose suspension. The internal construction is of B. T. H. standard practice.

The control is the Sprague Thomson-Houston multiple-unit system, and is similar to that used on the passenger trains equipped for the Metropolitan Railway by the British Thomson-Houston Company.

The collector gear consists of twelve shoes arranged as follows : Two positive shoes in parallel on each side of each truck which are supported by oak beams bolted to the axle boxes. There are four negative shoes, one being attached by a suitable insulated bracket to each motor.

The following are the leading dimensions :

Gauge	4 ft. 8 $^{1}/_{2}$ in.
Length over cab and headstocks	30 ft. 0 in.
— over buffers	33 ft. 6 in.
Centres of bogies	17 ft. 0 in.
Wheel-base of each bogie	7 ft. 6 in.
Width over cab	8 ft. 0 $^{1}/_{4}$ in.
— over side sills	8 ft. 0 in.
— overall	8 ft. 7 in.
Height from rails to top of cab	12 ft. 3 $^{7}/_{8}$ in.
— — — of floor	4 ft. 7 $^{1}/_{2}$ in.
Diameter of wheels	3 ft. 2 in.
— of axles at centre and in motor suspension bearings	0 ft. 6 $^{1}/_{2}$ in.
— — at gear wheel seat	0 ft. 7 $^{1}/_{2}$ in.
— — at wheel seats	0 ft. 7 $^{7}/_{16}$ in.
— — at truck journals	0 ft. 5 $^{1}/_{2}$ in.
Length of journal	0 ft. 9 in.

The trucks are of the pressed steel type strengthened with reinforcing plates, steel angles and gussets, and are fitted with a swinging bolster, built up with steel sections and steel castings. The bolster is supported on two nests of coil springs of circular section, each nest consisting of three springs. The bolster is also provided with cast steel wearing plates, centre and side bearing plates. The side frames are supported on the axle boxes by laminated springs of heavy design. The axle boxes are of steel castings, machined to work in the horn plates which are also of steel castings and machined, being riveted to the side frames which are cut out to receive them. The side frames are further strengthened at this point by a doubling plate. The axle boxes are provided with removable fronts, each front of which is fitted with an inspection door, the bearings being of anti-attrition metal. The axle-boxes are provided with lugs at the bottom to which the collector shoe beams are attached. Very ample provision is made for lubrication and the exclusion of dust. The brake gear is of the inside type, one block per wheel being provided, the whole being of specially heavy design so as to stand operation by both power brakes simultaneously. The wheels have centres of wrought iron, with nine open spokes forged into them. The motors are carried on the transoms by means of cast steel brackets riveted thereto, in which the nose on the motor rests, being held there by a forged strap. Collector shoe beams are of oak, and bolted to the axle-boxes on each side of each truck, the collector-shoes being hung inside the wheel-base.

The underframe is constructed of steel members of sufficiently heavy section to bring up the locomotives to the weight desired. At each end of the underframe are placed buffers, and draw-hooks with screw coupling of standard English pattern, besides a central automatic coupler, so that the locomotives can be used for hauling either standard coaches or electric stock.

The cab, of the box-wagon shape with curved roof, is constructed of steel plates, $^1/_8$ inch thick, riveted to supporting vertical and longitudinal angles, which are in turn riveted to the underframe. At each end of the cab, there are four movable windows, three being dropping lights, and one hinging inwards. There is also one dropping light at each side, in the corners.

Hinged doors are fitted at each side of the locomotive at the ends, there being two single doors and two double doors, the double doors for use whenever it is necessary to remove the exhausters, compressors, etc., from inside the cab.

The locomotive is fitted at each end with complete driving equipment, consisting of master controller, provided with " deadman's " handle, air and vacuum brake, driver's valves, starting switches for exhauster motors, valves for air-operated whistle and sanding gear, air and vacuum gauges and ammeters; also at each end of the cab, to the right of the driving equipment, is fitted a column to carry the hand-brake gear.

The control and brake equipment is, as far as possible, divided into two sets, and placed on either side of the locomotive, leaving a gangway down the centre. The control itself is entirely divided into two sets, one set for each two motor equipments.

Taking each side of the locomotive, the arrangement is as follows :

On one side — switchboard, containing the necessary main, control and cut-out switches, compressor motor switch and main lighting switch ; control gear, consisting of contactors, resistance and circuit gear, all mounted on a strong steel frame rigidly connected to the cab sides and underframe. Underneath this is fixed the reverser. The air compressor, main air and vacuum reservoirs, being placed in line with the supporting frame.

On the opposite side of the locomotive, looking from the same end, are arranged two motor-driven vacuum exhausters, and control gear on framework, arranged as above, together with switch-board containing the necessary control switches, etc., with the addition of the main

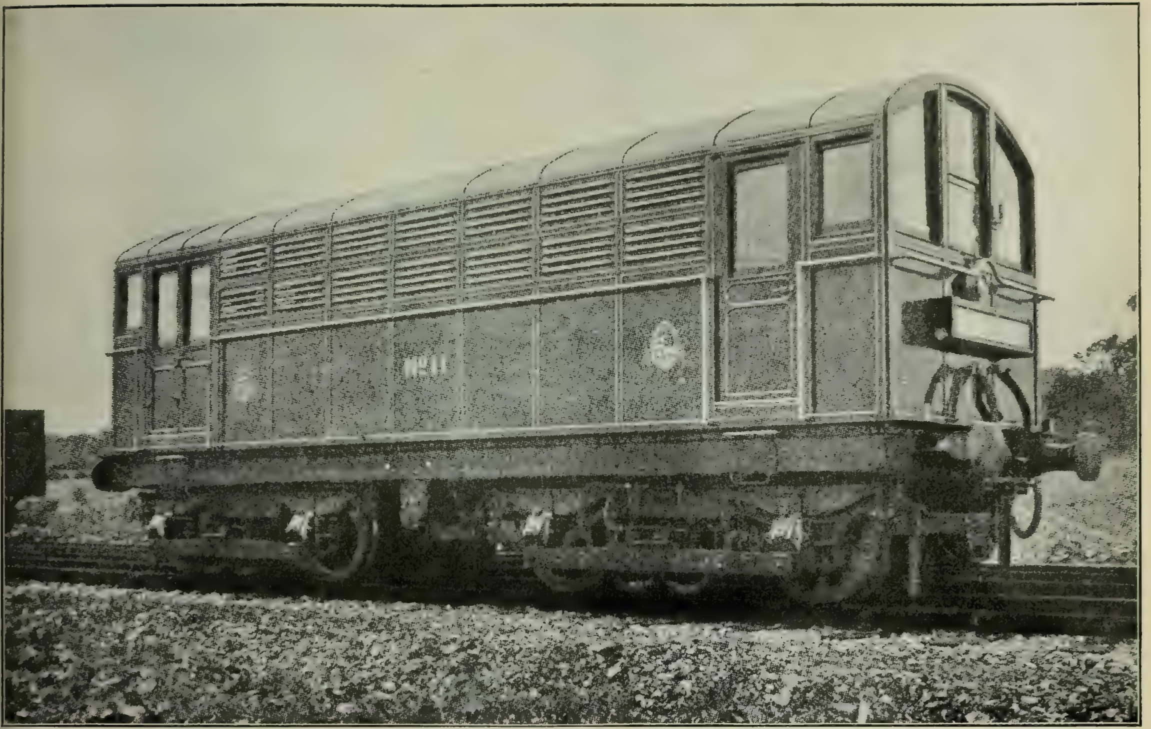


Fig. 12. — New electric locomotive, Metropolitan Railway. — Right side view.

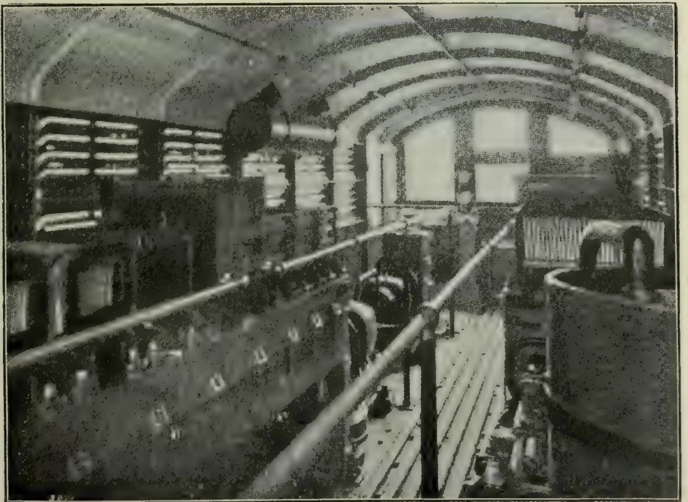


Fig. 13. — View of interior.

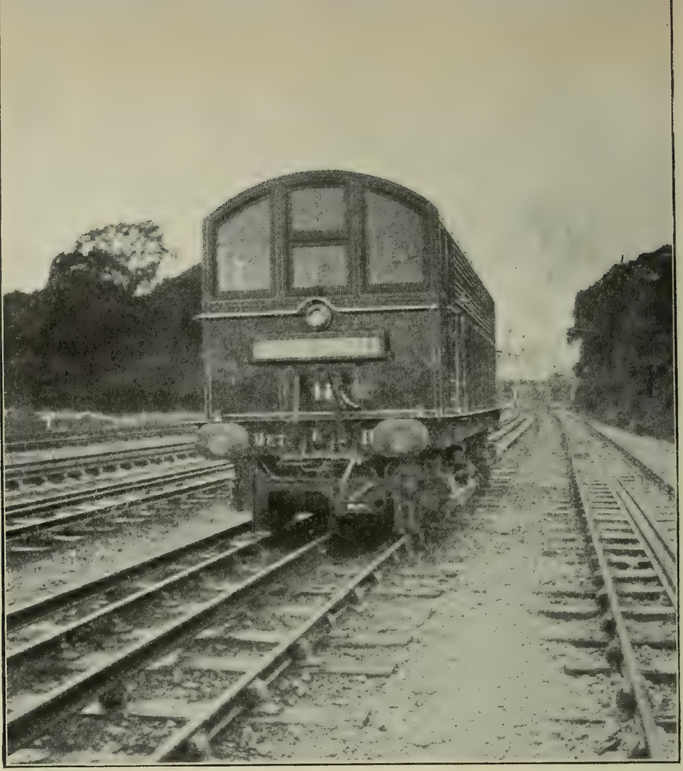


Fig. 14. — Electric locomotive, Metropolitan Railway. Front view.

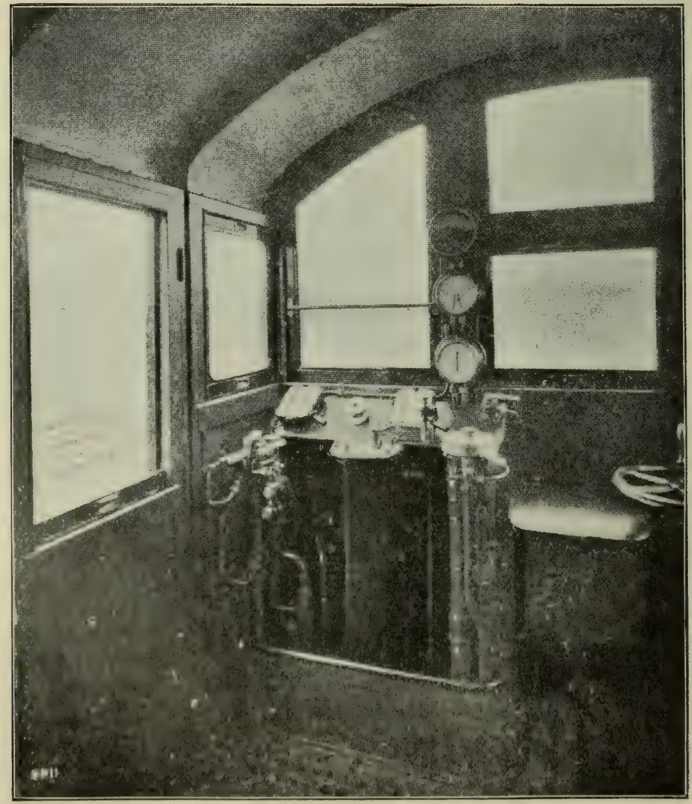


Fig. 15. — Control gear, electric locomotive, Metropolitan Railway.

switches for the vacuum exhausters. The auxiliary reservoir for the air brake is fixed in the cab over the exhausters.

The air brake is of the quick-acting pattern, air being supplied by a B. T. H. electrically-driven compressor of the C. P. 23 type. This set will operate against a pressure of 90 lb. per square inch, and has a cylinder displacement of 50 cubic feet per minute.

In connection with the vacuum brake, there are provided two exhausters each electrically-driven by a B. T. H. type DA motor. One of these exhausters is used for creating the vacuum when starting the train, the other (continuously in operation at half speed) for maintaining the vacuum whilst running.

In the underframe, there are fixed two air brake cylinders of the vertical type, 13 inch diameter, and two vacuum cylinders, 22 inch diameter. Immediately under the above, are two transverse rocking shafts to which the pistons of the cylinders are connected, *viz.*, one air and one vacuum to each shaft; each set in turn being connected to the rigging for one truck. It should be noted, however, that the hand brake wheel at either end of the cab operates the brake rigging on both trucks.

Trip cocks, one for air and one for vacuum, are fitted on each truck.

Power sanding gear is provided, a sand hopper being fitted at each end of the locomotive in the cab, under which is fixed a combined air and sand valve, the sand and air being carried by a flexible pipe to the fixed delivery pipes on the leading end of each bogie.

Four lighting circuits are provided, one of five lamps placed in the roof down each side of the locomotive, and one of five lamps at each end of the locomotive, the distribution of the light in the latter being four lights in the destination indicator and one in the headlight. All the lamps are of 16 c. p., and are arranged for working five in series on a 600 volt circuit. Provision is also made at each end of the locomotive for the reception of the necessary oil signal lamps to suit the traffic requirements.

All cables are asbestos covered, and are run in drawn steel tubing fitted in the sub-floor wherever possible. The connections between contactors and rheostats are of copper rod. The necessary connection boxes are fitted in the sub-floor and underframe for connecting to the motors and colllector shoes.

Each locomotive when operating on a 600 volt circuit is capable of hauling a 120-ton passenger train on the level at a speed of 35 miles per hour, and of starting with the same load on a grade of 1 in 44; also of hauling a 250-ton goods train up a grade of 1 in 44, and starting with the same load on a grade of 1 in 90.

[625 .241]

5. — Special service wagons; Great Central Railway Company.

Figs. 16 to 26, pp. 1193 to 1196.

(*Engineering.*)

In addition to their ordinary stock for handling goods traffic, the railway companies all possess a number of wagons, whose use is confined to the carriage of special forms of goods which are either too bulky or of awkward shape, or else of too great weight to be accommodated in the ordinary goods wagons on flat tracks.

We give drawings of several special-service wagons on the Great Central Railway.

Figures 16 and 17 are drawings of two types of twin wagons. The type of truck shown in figure 18 is one which is especially useful for boilers. Each truck of the pair shown in figure 16 will carry 20 tons, with a tare each of 8 tons 13 cwts. The three axles are 5 ft. 6 in. apart, the wheels 2 ft. 9 $^1/_2$ in. in diameter, and the frame 19 ft. 6 in. long over headstocks. Standard buffers are provided at the outside end. Between the twin trucks the headstocks are provided with a special coupler, and wooden bumpers rounded off to a radius are fitted to the headstocks. A hand-brake is provided on one side of each truck, braking on to two axles.

The wagon shown in figure 17 is of a heavier type, and each truck in this case carries 30 tons. These trucks are made up of old tender frames. They are 19 feet over headstocks, have a wheel-base of 12 feet, and six wheels 3 ft. 11 in. in diameter. A brake lever on one side applies blocks to the outside of the leading and trailing wheels. This stock is provided with continuous draw-bar. Each truck is fitted as shown in figure 17 with a central swivelling bolster.

A six-wheeled truck used for carrying locomotive boilers up to 20 tons in weight, is shown in figures 18 and 19. Figure 19 shows an elevation of the vehicle, while figure 18 gives a longitudinal section of the frame. The tare of this truck is 8 tons 18 cwts.; length on headstocks, 25 feet, with a 17-foot wheel-base. The wheels are 2 ft. 9 $^1/_2$ in. in diameter, and two pairs are braked with a one-side-only lever gear. The floro-plating in $^1/_4$ inch tick. Wells, 8 $^5/_8$ inches deep, are provided in the floor, for the purpose of receiving the fire-box or projecting plates at the smoke-box end of a locomotive boiler.

The figures 20 to 24 are of special bogie wagons. The type illustrated in figures 20 and 21 is a special skeleton boiler-truck. From figure 20 it will be seen that the central longitudinals are arranged as low as possible, their upper side being 3 ft. 1 $^5/_8$ in. above the rail level, while from the rail to the top side of the sole-bars is 3 ft. 10 $^5/_8$ in. The centre longitudinals are of channel section, 12 inches deep; the sole-bars of channel, 9 inches deep.

The frame is 36 feet long over headstocks. It is supported on two four-wheel bogies, built up of plate-frames and centred 23 ft. 6 in. apart. The wheel-base of the bogies is 5 ft. 6 in.; the wheels are 3 ft. 1 in. in diameter. Outside bearings and springs are provided as shown. The sole-bars and longitudinals are stiffened with under-stays. This truck will carry a load of 40 tons with the low tare of 14 tons 12 cwt.

Figures 22, 23 and 24 show three examples of bogie well-wagons. The type shown in figure 22 is designed for a load of 25 tons, and has a well 31 ft. 3 in. long; that shown in figure 23 has a well 32 feet long, and carries a load of 40 tons; and that in figure 24 carries a load of 50 tons with a well 25 feet long.

The 25-ton wagon in figure 22 has bogies centred 42 ft. 3 in. apart, the bogie wheel-base being 5 ft. 3 in. The bogie frame is built up of plates and angles, and the main frame is suspended from it by 2 $^1/_4$ inches rods, fitted with ball-and-cup sockets to accommodate the motion of the bogie. The draw-gear and buffers are fitted to the bogies. These wagons are 52 ft. 2 in. long over headstocks.

The sole-bars are of 18 by 7 inches joists, strengthened with plates in the centre.

The tare of this wagon is 20 tons 13 cwt. The upper side of the cross-girders in the well are only about 15 inches above the rail-level.

The 40-ton wagon shown in figure 23 has a tare of 30 tons. The distance between centres of bogies is 44 feet. The wheels of this wagon are larger than in the other types above mentioned, being 4 ft. 6 in. in diameter. As in the case of the previous type, the draw-gear and buffers are fitted to the bogies of this wagon. The main frame is also suspended by links from the bogie frame.

Figs. 16 to 26. — Special service wagons; Great Central Railway Company

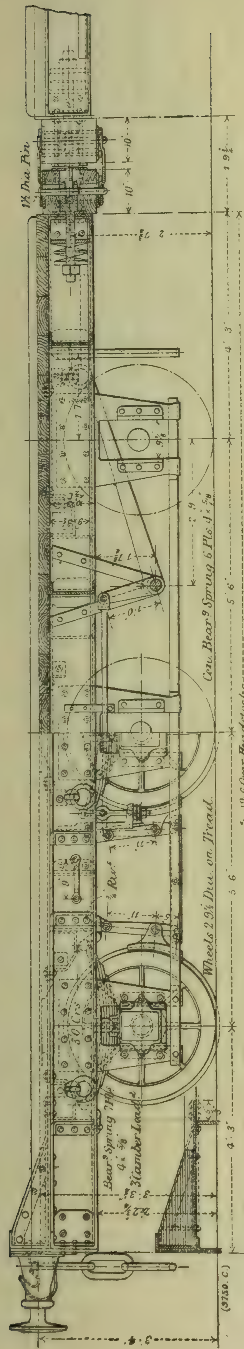


Fig. 16.

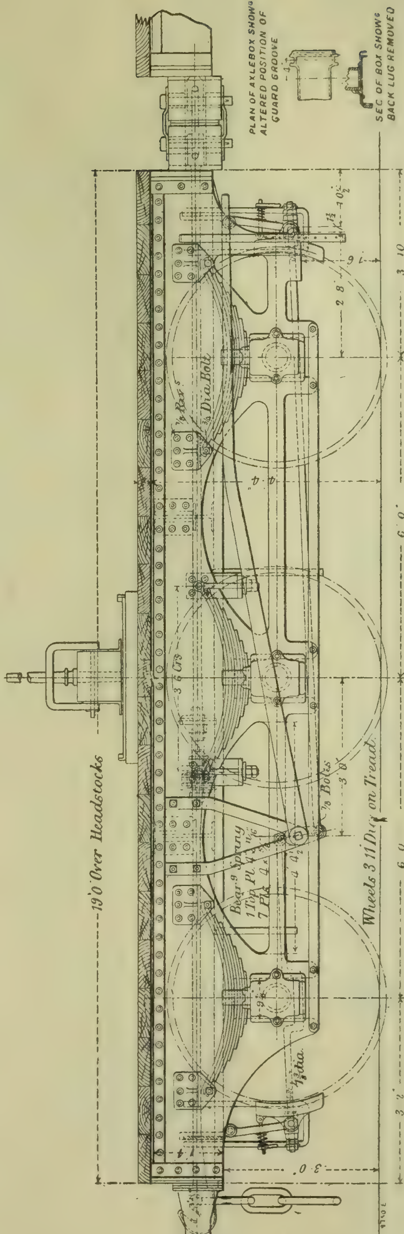


Fig. 17.

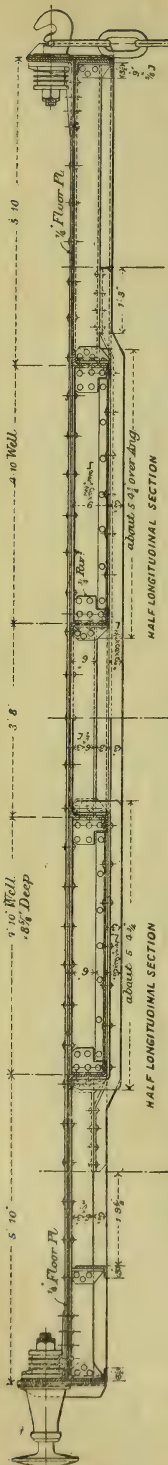


Fig. 18.

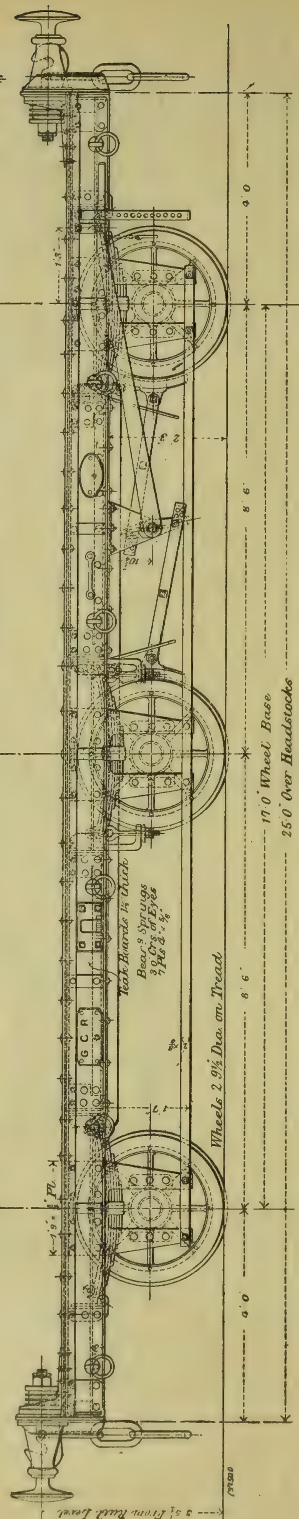


Fig. 19.

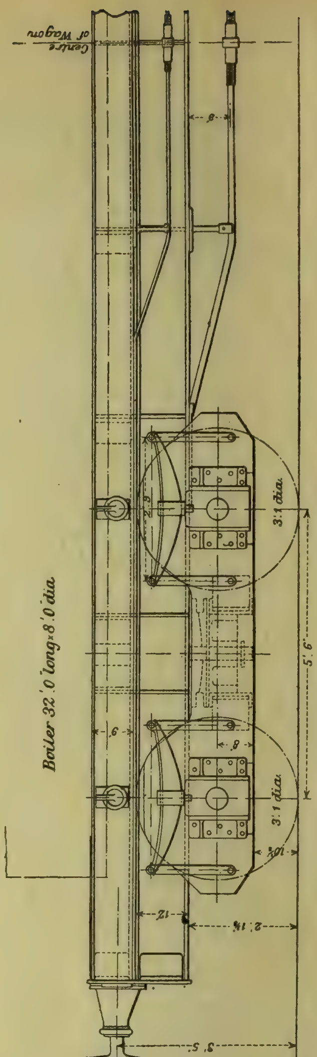


Fig. 21.

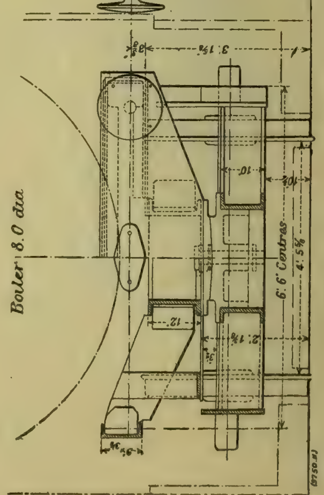


Fig. 20.

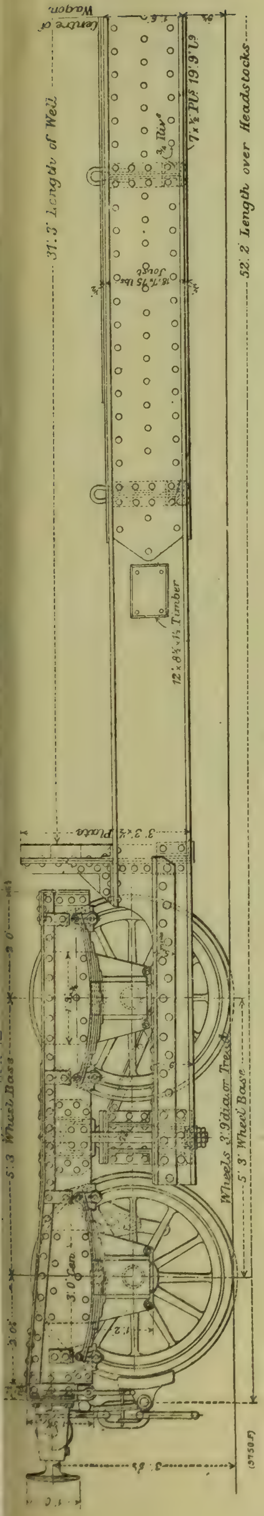


Fig. 22.

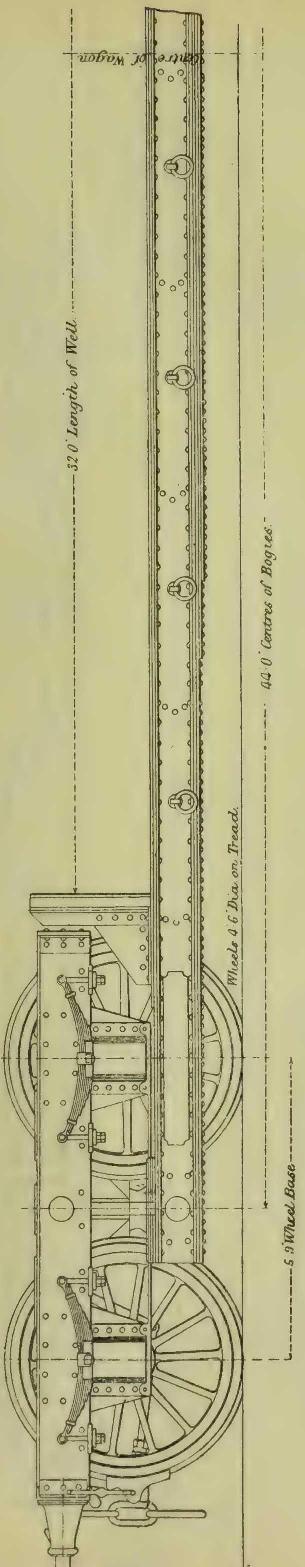


Fig. 23.

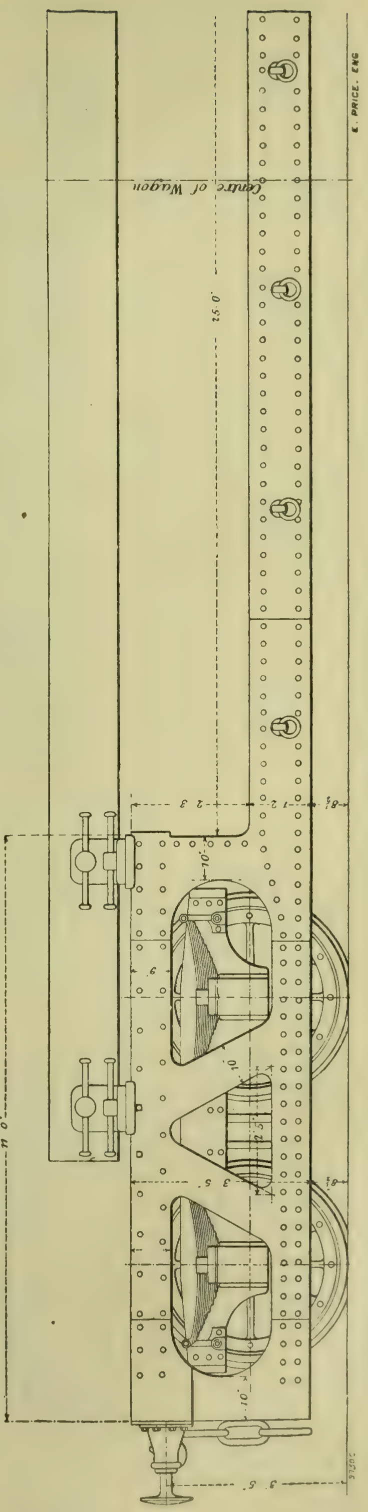


Fig. 24.

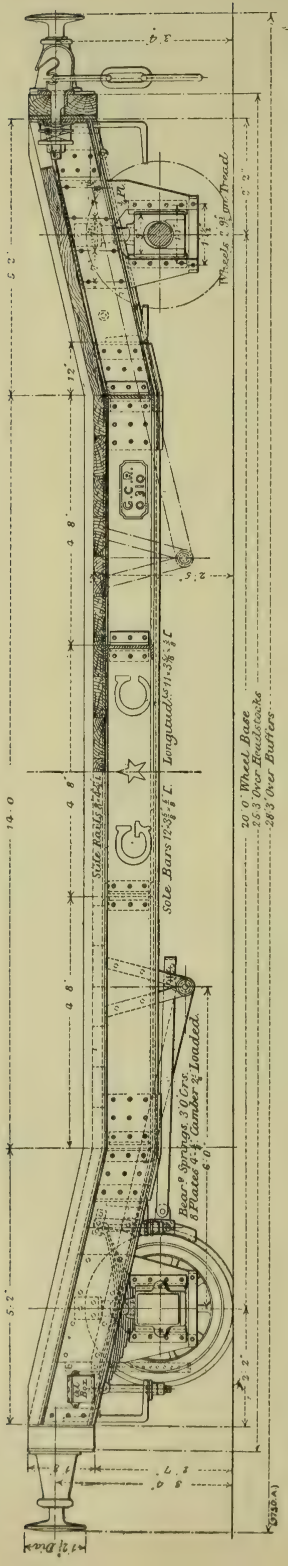

3.4
2.2
Wheels 2'9½" on Tread
5.2
12
4.8
14.0
4.8
G.C.R. 0310
2.6
Sole Rails
Sole Bars
Longitud.ls
20.0 Wheel Base
25.3 Over Headstocks
28.3 Over Buffers
Bear.g Springs 3'0" Crs.
8 Plates 4"×⅜" Camber 2¼" Loaded.
6.0
5.2
2.2
2.7
3.0
1½ Dia

Fig. 25.

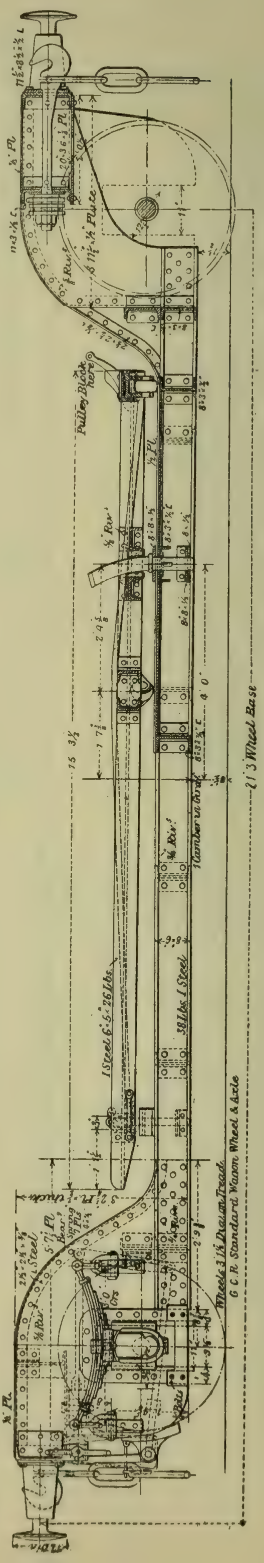

⅜" Pl
Pulley Block here
½" Pl
⅝" Riv.
2.4⅝
1.7⅝
15.3½
4.0
1 Camber in Gird.
⅝" Riv.
38 lbs I Steel
I Steel 6"×5"×26 lbs.
Wheels 3'1½ Diam Tread
G.C.R. Standard Wagon Wheel & Axle
2.9
21'3 Wheel Base
⅜" Pl
1½ Dia

Fig. 26.

The 50-ton wagon (fig. 24) has a length over headstocks of 47 feet, and a tare of 32 tons 17 cwt. This truck is used for such work as carrying armour-plates, and loading-beams, as shown, are provided for this purpose. The floor of the well is 1 ft. 10 1/2 in. above the rail-level. The sole-bars 1 ft. 2 in. deep at the well, made up of plates and angle-irons. The bogies are enshrouded in the main frames. In this case the draw-gear, etc., is fitted to the main frames.

In figure 25, we give a half elevation and section of a 20-ton machine four-wheeled wagon on the Great Central Railway. The tare weight of this wagon is 9 tons 14 cwt. Its length is 25 ft. 3 in. over headstocks, with a wheel base of 20 feet. The floor level is 2 ft. 7 1/2 in. above the rail. The sole-bars are of 12 inches by 3 5/8 inches by 5/8 inch channel, The wheels are 2 ft. 9 1/2 in. in diameter, and the axles are provided with both outside and inside boxes. The headstocks are provided with wooden beams. Four rings with chains and screw shackles are provided on the floor of the wagon for securing the load. Side rails are provided, standing 2 inches above the floor.

Figure 26, gives a half elevation and half section of a truck specially designed to take road-wheeled vehicles such as fire-engines. This wagon is fitted with a carrying table in the well. This table is provided with rollers and a pivot, and may be swung round and dropped on to the ground so as to form a ramp for the vehicle to be loaded. This carrying or turntable is fitted with wheel tracks. It also has an arm at the inboard end, and to this arm block and tackle may be fixed to haul the great engine up the ramp. When the vehicle has been drawn up so far that it balances on the table, the whole may be swung round to a position parallel with the wagon, when the table is locked to the wagon floor or frame. The wheel-base of this wagon is 21 ft. 3 in. long, the four wheels being 3 ft. 1 1/2 in. in diameter. One side only is braked.

[656 .253]

6. — The Hall electric slot.

Figs. 27 and 28, p. 1198.

(*Railroad Gazette.*)

The Hall Signal Company's electro-mechanical slot for semaphore signals combines in a marked degree reliability, simplicity and accessibility. To reduce failures to a minimum, such an apparatus should be easily understood, and easy to inspect and repair. A slot placed at or near the arm of a high signal is not, under the most favorable circumstances, easy of access. A small case, necessitating excessive compactness aggravates this condition. The placing of moving parts, such as levers and dogs, behind any other part, necessitating the removal of the latter to make repairs to the former, is a nuisance, and wires connected to moving magnets are liable to cause failure. This slot, shown in the accompanying illustration, is free, to a remarkable extent, from the evils mentioned. It is designed to be mounted near the base of the signal post, where it will be easily accessible to the maintainer. All movable parts can be plainly seen and easily inspected or removed without dismembering the entire mechanism. The case is roomy but not over large, and the magnet is fixed. The details and construction are shown in figure 28. In this drawing, A represents the cast-iron case; B is the lower operating rod and C the upper operating rod carrying the dash pot Q, attached in the usual way. D is a powerful iron-clad magnet mounted on a stand which is rigidly fastened to the case; E is the armature secured loosely to the lever F by the threaded pin G. G is slightly smaller than the hole in F,

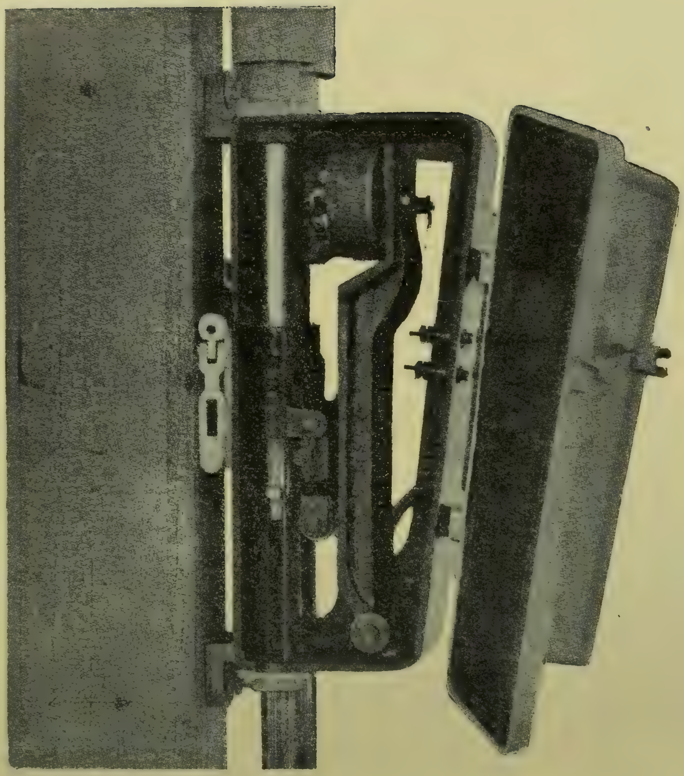


Fig. 27. — Double electro-mechanical slot. Doors open on both sides.

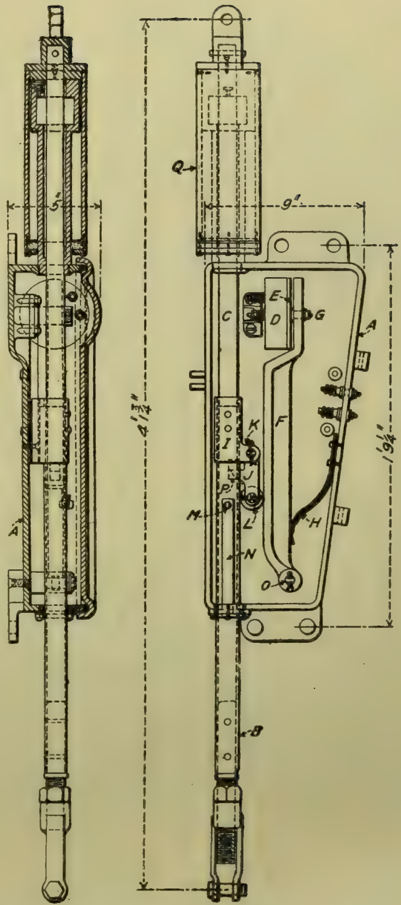


Fig. 28. — Hall slot for semaphore signal.

through which it passes, and has a semi-spherical head, after the manner of a ball and socket joint. This is to allow E to make good contact with D despite any small lack of adjustment in F. Lever F is pivoted at O. H is a phosphor bronze spring used to restore lever F to its normal position, but exerts no appreciable pressure otherwise. I is a cast-iron sleeve riveted to the lower rod B, and carries the latch J pivoted to the lug K, which is part of the sleeve I; J carries a roller L to reduce friction when traveling against lever F. The lower end of C extends within B and carries a pin M working in slot N cut in B. This is to allow the signal to be pulled to danger, as M projects beyond the edge of B on both sides. Both rods are notched at P to allow the projection of latch J to engage with upper rod C.

When the magnet D is energized, the signal can be cleared. The magnet holds F against J by pressing against roller L, and then if B is raised C must also go up for latch J will engage with lower end of C. If, while the signal is in the clear position, magnet D becomes de-energized, as by the opening of a track relay, the weight of the spectacle acting against lever F, through C and latch J will force F away from D; and J, in tripping, will allow C to pass by, and the signal will assume the stop position.

When F is forced away from D it compresses spring H, which remains compressed until B has been restored by the signalman to its normal position, allowing J again to enter the notch P; when this occurs H restores F to contact with D. If it is attempted to clear the signal when D is de-energized, F will be forced back in the same manner as above described.

The double slot, shown in figure 27, is used where two arms of a signal are slotted, and is much more compact and convenient than two single slots. This slot consists essentially of the mechanisms of two single slots mounted side by side in one case, and it operates exactly as above described. The principal dimensions of both slots are shown in figure 28. The single slot weighs approximately 85 lb., and the double slot approximately 145 lb. The slots will operate on 0·12 watt, and are highly efficient.

[625 .252]

7. — Either-sides brakes.

(*The Engineer.*)

In April, 1906, Mr. Lloyd-George selected colonel Yorke, R. E., Mr. Bell, M. P., and Mr. Robert Turnbull to form a committee to examine and test appliances intended to promote the safety of men employed in railway service. Among other matters, they were called upon to consider "either-side" brakes, and they have presented a report on the question to the Board of Trade. The normal wagon is fitted with a long lever, which acts by a toggle joint on two brake blocks, which press on the wheels. The lever works at its outer end in a guide, which is notched, and when pressed down, by pulling is a little to one side, it is held by a notch, and, being more or less elastic, the brake blocks are forced hard against the wheels. In many cases a pin put through holes in the plates of the guide keeps the brake lever down, Inasmuch as the brakes can only be applied from one corner of the wagon, shunters have frequently to cross from one side of a train or a wagon to the other, thereby incurring imminent risk. This could be entirely obviated and some lives, to say nothing of limbs, saved if a brake could be devised which could be used from either side. At first sight this seems to be a very simple mechanical problem. In reality, after inspecting fifty-one models and sixty-nine fullsized brakes, the committee have arrived at the conclusion that not one solves it.

To provide an either-side brake presents no difficulty whatever. It is only necessary to duplicate the existing arrangement. Each side of the wagon would have its own brake. The problem lies, not in putting the brake on, but in getting it off. Two shunters, A and B, are at work, one at one side of a train, the other at the other. A puts on his brake and the train runs away from him into the charge of B. But B cannot take the brake off without crossing from his own side to A 's side, which is just the thing to be avoided. The conditions are quite inimical to any delicate or highly finished or complex fittings. The committee have thus defined them : " Ease of application ; ease of release ; security in locking the brake after application, although subjected to such shocks as may be incurred in working ; means of holding off the brake under similar conditions ; uniformity in the position of the levers on both sides of a wagon — namely, on the right side of a man when facing the wagon ; simplicity of design ; and sufficiency of braking power." But this is not all. The committee find that, even though in some cases fairly satisfactory in other respects, not a single invention was submitted to them that was not open to the objection that injury might result to a man at one side of the train by the action of another man at the opposite side either applying or releasing the brake, each being in ignorance of the other's presence. Night is in all cases the time of danger, and no appliance can promote the safety of railway men which will not work as well on a dark, wet night, in frost, or wind and snow, as well as it will at noontide of a summer day. As an illustration of the difficulties with which the inventor has to contend, it may be said that the committee decided that a very efficient rest must be provided for the lever when the brake is off, simply because shunters and others are in the habit of using the lever as a step on which to climb into the wagon. To make this rest come into line with other conditions was found impossible. The committee admit that the men should not climb into wagons off the brake lever. They say, however, very wisely : " We feel that we have to take facts as we find them, and as we are sure that it would be impossible to prevent men from standing on brake levers so long as these are placed in their present position, we have been forced to the conclusion that the condition as to the provision of a stop or rest for the side lever in the ' off ' position cannot be relaxed. It is, however, in this particular that the principal difficulty has arisen, and the majority of the designs submitted to us have failed. " And this because it was impossible to get the two levers off their " rests " with certainty at the same time.

Under the circumstances, the committee have taken the wisest course. They have abandoned the idea that the brake must admit of being released as well as put on from either side, and have contented themselves with stipulating that all wagons shall have two brakes of the ordinary kind instead of one. This, it may be taken, reduces risk at least one-half, inasmuch as the shunter will now only have to cross to take a brake off, instead of having to cross both to take it off and put it on — two separate operations occurring at different times. The members of the committee have embodied their views in a set of regulations running as follows, which they wish to take the form of a rule made by the Board of Trade : " 1° All wagons constructed after a certain date (say three months from the date of the rule) shall be fitted with a brake lever on each side in the ' cross cornered ' position in such a way that sufficient brake power can be applied to the wheels by either of such levers ; 2° all wagons which are at present fitted with a brake lever on one side only shall, within a period of seven years from the date of the rule, be fitted with an additional lever in the ' cross cornered ' position on the other side, in such a way that sufficient brake power can be applied to the wheels by either of such levers, and all wagons which are at present without brakes shall be fitted with two levers in a similar manner within the same period ; 3° all wagons at present fitted with a brake lever on each side in the ' single ended ' position shall, within a period of ten years from the date of the rule, have levers rearranged in such a way as to comply with the conditions in 1° and 2°, and 4° no wagon for service shall be fitted hereafter with an either-side brake as defined in the report unless it has been approved by the Board of Trade on the advice of the committee. "

These recommendations are not without their humorous side. The wagon which ten years hence will be worth fitting with a brake is a curiosity. But wagon owners will not complain that the time is long. Even if the second brake did not cost more than a pound sterling, the number of wagons to be fitted is so enormous that the aggregate outlay must represent a very large sum. As a result of inquiries which were addressed to the railway companies of the United Kingdom, the committee have ascertained that the total number of vehicles owned by them to which a hand-lever brake is applicable is nearly 750,000. Of these about 172,000 are now fitted with brakes capable of being applied on both sides, while 33,000 are fitted with brakes of various designs, which are capable of being applied and released from either side. It is probable that, in addition to the above, there are 650,000 wagons belonging to private traders, making a total of 1,400,000 wagons in the United Kingdom. It is not unusual for a railway company to own 50,000 or 60,000 wagons. To withdraw these from service all at once, or even in large numbers, to be fitted with the second brake, would be productive of serious inconvenience. Almost all changes in the working of our highly organised railway system must perforce be carried out slowly. No doubt many well-meaning persons will say that to postpone the alteration for ten years is a grave error. But it may be replied that those who are responsible are all three men most intimately acquainted with the working of railways, who fully understand what is and is not possible; and no one, we think, will dream of accusing Mr. Bell of neglect of the best interests of the railway servants of the kingdom. Besides, the percentage of preventable accidents is so small that there is no special reason for haste. An examination of the returns of accidents reported to the Board of Trade during 1905 and 1906, shows that in 1905, two men were killed and fifteen were injured through the want of a lever to apply the brake on the side of a wagon at which the man happened to be, and three men were injured through not being able to release the brake from the side opposite to that on which it had been applied. The corresponding figures for the year 1906 are two fatal and twenty non-fatal when applying, and one fatal and four non-fatal when releasing.

The whole transaction, the raising of the question, the proceedings of the committee, the energy of inventors, are all instructive, bringing into the light as they do the difficulty which often attends the solution of an apparently quite simple mechanical problem. It consists here, not in devising mechanism which will do what is wanted, but in producing something which will satisfy conditions which are only remotely connected with mechanism Under existing conditions, as trains are made up haphazard, the shunter finds the brake now at his own side of the wagon and now at the other side of it. If there was a brake at both sides, crossing would cease to be necessary, no matter how the train was made up. The brake lever would always be ready to his hand. This is the view taken by the committee, and it will probably be found ultimately that if their recommendations do not completely meet the case, they will, at all events, entail the doing of all that can be done.

[725 .31]

8. — Raising and moving the Antwerp-Dam station building.

In order to complete the raising of Antwerp central station and of the lines ending there, it is still necessary to raise and double part of the Antwerp-Esschen line. Antwerp-Dam station is on this line, and in order to enable the work in question to be carried out, this station must be raised and moved a certain distance to the left, as it is not possible to purchase any land to the right of the railway for the second track.

Antwerp-Dam station, which was built in 1884 of selected material, suits the requirements of the traffic perfectly and has architecturally a very pleasing appearance. To pull it down and rebuild it on the new site would require two seasons, and would cost, at present prices, about 120,000 francs (£4,800).

The Administration, to save time, decided to move the building as a whole, and entrusted this work to Messrs. Morglia and Weiss.

The horizontal ditplacement required is 36 metres (118 feet) and the building is to be turned through an angle of about 10°.

The contract price for the whole work is 90,000 francs (£3,600), including new foundations consisting of a bed of concrete 65 centimetres (2 ft. 1 $^9/_{16}$ in.) thick.

We think that this is the first time that work of this kind will have been done in Belgium. When it has been finished, complete details of how it was carried out will be published in the *Bulletin*.

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PUBLISHED UNDER THE SUPERVISION OF

L. WEISSENBRUCH,

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Recueil de types de ponts pour routes en ciment armé, calculés conformément à la circulaire ministérielle du 20 octobre 1906.

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Festigkeits- und Massennachweise für gewölbte Eisenbahn- und Strassenbrücken von 1 bis 16 Meter Weite.

Malstatt-Burbach, Verlag des Verfassers. In Folio, 8 Seiten Text und 76 Seiten Zeichnungen. (Preis : 5 Mark.)

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Zentralblatt der Bauverwaltung. (Berlin.)

1907 **624** .8
Zentralblatt der Bauverwaltung, Nr 73, 7. September, S. 484.

OTTMANN & LOEBELL. — Eisenbahndrehbrücke im Duisburg-Ruhrorter Hafen. (2 200 Wörter & Abb.)

In English.

American Engineer and Railroad Journal. (New York.)

1907 **621** .132.5
American Engineer & R. Journal, September, p. 338.

Mallet articulated compound locomotive, 0-8-8-0 type. (2,000 words, 1 table & fig.)

907 **621** .131.3
erican Engineer & R. Journal, September, p. 342.

ome important results from the Pennsylvania Railroad ing plant at St. Louis. (150 words & 1 table.)

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907 **621** .138.2
erican Engineer & R. Journal, September, p. 346.

sh handling plant. (400 words & fig.)

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lletin of the International Railway Congress Association. (Brussels.)

907 **621** .132.8
etin of the Railway Congress, No. 9, September, p. 855.

RAHM. — Automotors and light trains on the lish railways. (1,800 words & fig.)

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07 **625** .142.4 (.73)
etin of the Railway Congress, No. 9, September, p. 861.

AMP (W. M.). — Experiments with reinforced crete ties in America. (4,200 words & fig.)

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07 **625** .143.2 (.73)
etin of the Railway Congress, No. 9, September, p. 869.

or better rails. (6,900 words, 1 table & fig.)

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07 **385**. (07.2 & **621** .131.3
etin of the Railway Congress, No. 9, September, p. 892.

ocomotive testing plant of the Pennsylvania Rail-
l at Altoona. (3,100 words & fig.)

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07 **625** .2 (06 & **625** .216
etin of the Railway Congress, No. 9, September, p. 901.

ests of Master Car Builders' couplers. (5,600 words
g.)

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07 **656** .256.3
etin of the Railway Congress, No. 9, September, p. 914.

. new system of block signalling on the Pennsylvania
lroad. (3,200 words & fig.)

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07 **313** .385 (.3)
etin of the Railway Congress, No. 9, September, p. 921.

he world's railways. (2 tables.)

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07 **656** .257
etin of the Railway Congress, No. 9, September, p. 926.

he completion of the electric signalling system at
ssels Nord Station. (2,500 words & fig.)

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07 **625** .14 (01 & **625** .2 (01
etin of the Railway Congress, No. 9, September, p. 932.

heel and rail of electric railways. (1,400 words.)

1907 **62**. (06 & **385**
Bulletin of the Railway Congress, No. 9, September, p. 934.

The railways at the conference of the Institution of civil engineers. (1,900 words.)

1907 **385**. (01 (.57)
Bulletin of the Railway Congress, No. 9, September, p. 937.

Trans-Siberian Railway service. (2,400 words.)

1907 **625** .4
Bulletin of the Railway Congress, No. 9, September, p. 940.

The scheme for an overhead railway in Berlin. (900 words.)

1907 **625** .245
Bulletin of the Railway Congress, No. 9, September, p. 942.

New air brake instruction car : Chicago, Burlington & Quincy Railway. (1,000 words & fig.)

1907 **621** .132.3
Bulletin of the Railway Congress, No. 9, September, p. 946.

Four-cylinder compound locomotive for the Italian State Railroads. (2,900 words & fig.)

1907 **621** .132.5
Bulletin of the Railway Congress, No. 9, September, p. 955.

Compound locomotive, St.Gothard Railway. (850 words & fig.)

1907 **656** .211.5
Bulletin of the Railway Congress, No. 9, September, p. 956.

Electric baggage trucks. (550 words & fig.)

1907 **625** .3
Bulletin of the Railway Congress, No. 9, September, p. 959.

The gyroscope mono-rail railway. (2,400 words & fig.)

1907 **656** .253
Bulletin of the Railway Congress, No. 9, September, p. 963.

Illuminating semaphore signals. (1,100 words & fig.)

1907 **625** .216
Bulletin of the Railway Congress, No. 9, September, p. 967.

Gould friction draft gear. (450 words & fig.)

1907 **625** .252
Bulletin of the Railway Congress, No. 9, September, p. 968.

Armbrust brake shoe. (500 words & fig.)

1907 **016** .385. (02
Bulletin of the Railway Congress, No. 9, September, p. 113.

Monthly bibliography of railways. — Books. (35 labels.)

907 **016** .385. (05
letin of the Railway Congress, No. 9, September, p. 116.

Ionthly bibliography of railways. — Periodicals. 5 labels.)

Engineer. (London.)

907 **621** .132.1 (.42) & **625** .232 (.42)
gineer, No. 2696, August 30, p. 209.

Recent locomotives and carriages on the L. & Y. lway. (1,900 words & fig.)

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907 **624** .52
gineer, No. 2697, September 6, p. 231.

'he Quebec bridge. (2,600 words & fig.)

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907 **621** .132.1 (.73)
gineer, No. 2698, September 13, p. 253.

'he locomotives of the Atchison, Topeka & Santa Fe lway. (2,700 words, 6 tables & fig.)

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907 **656** .222.1 (.44)
gineer, No. 2699, September 20, p. 279.

ROUS-MARTEN (C.). — Recent locomotive work on French Northern Railway. (2,800 words.)

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907 **621** .134.2
gineer, No. 2699, September 20, p. 286.

Express passenger engine, Midland Railway — The ve gear. (500 words, 2 tables & fig.)

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907 **385** .589
gineer, No. 2699, September 20, p. 291.

Railway unrest. (1,100 words.)

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907 **621** .132.5
gineer, No. 2699, September 20, p. 293.

Iallet compound locomotive. (1,200 words & fig.)

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907 **624** .2 (01
gineer, No. 2700, September 27, p. 305.

Continuous girders. (2,500 words & fig.)

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907 **385** .15
gineer, No. 2700, September 27, p. 318.

State railways. (1,200 words.)

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907 **656** .222.1 (.42)
gineer, No. 2700, September 27, p. 319.

ROUS-MARTEN (C.). — Longest non-stop run on eat Western Railway. (1,600 words.)

1907 **621** .133.2
Engineer, No. 2700, September 27, p. 324.

The repair of locomotive tube plates. (900 words & fig.) (S. *Bulletin of the Railway Congress*, No. 7, July, 1907.)

Engineering. (London.)

1907 **624** .52
Engineering, No. 2176, September 13, p. 351.

SKINNER (F. W.). — The Quebec bridge. (6,300 words & fig.)

1907 **656** .235.6
Engineering, No. 2176, September 13, p. 369.

Export railway rates in Austria-Hungary, Italy, etc. (2,000 words & 2 tables.)

Engineering Magazine. (London.)

1907 **385** .1
Engineering Magazine, September, p. 849.

GAINES (M. W.). — The value of railroad improvements. (3,600 words.)

Engineering News. (New York.)

1907 **621** .331 & **621** .388. (01
Engineering News, No. 8, August 22, p. 203.

HOPKINS (N. M.). — The development of standard lightning protection for power plant chimneys at United States navy yards. (3,500 words & fig.)

1907 **621** .133.3 (01
Engineering News, No. 9, August 29, p. 225.

Causes of leaks in locomotive boiler tubes. (1,300 words & fig.)

1907 **624**. (01
Engineering News, No. 12, September 19, p. 301.

PRICHARD (H. S.). — The proportioning of steel railway bridge members. (4,400 words, 1 table & fig.)

Great Western Railway Magazine. (London.)

1907 **656** .253
Great Western Railway Magazine, No. 10, October, p. 221.

Track circuit installation. (550 words & fig.)

Locomotive Magazine. (London.)

907 625 .233
omotive Magazine, No. 181, September 14, p. 167.

'he lighting of railway carriages. (700 words & fig.)

Permanent Way Institution. (London.)

907 656 .253
nanent Way Institution, Vol. XXV, Part. 2, August, p. 164.

OBLE (W.). — Fog-signalling and a suggestion. 00 words & fig.)

907 625 .151
manent Way Institution, Vol. XXV, Part. 2, August, p. 183.

COTT (H.). — The construction of crossings. (5,500 ·ds & fig.)

907 656 .257
manent Way Institution, Vol. XXV, Part. 2, August, p. 204.

USSELL (E.). — Signal department work. (12,000 ·ds & fig.)

Proceedings of the American Society of Civil Engineers. (New York.)

907 625 .13
ceed. of the Amer. Soc. of Civil Eng., No. 6, August, p. 599.

IEEM (J. C.). — The bracing of trenches and tunnels, h practical formulas for earth pressures. (6,000 words ig.)

Railroad Gazette. (New York.)

907 625 .235
lroad Gazette, No. 9, August 30, p. 234.

new pressed steel passenger car. (600 words & fig.)

907 621 .132.3
lroad Gazette, No. 9, August 30, p. 238.

'acific locomotive for the Pennsylvania Lines West. 100 words & fig.)

907 625 .143.2
lroad Gazette, No. 10, September 6, p. 250.

ail sections and specifications. (5,400 words.)

907 621 .132.3
ilroad Gazette, No. 10, September 6, p. 258.

Pacific locomotive for the Lake Shore & Michigan thern. (1,100 words & fig.)

1907 385 .1 (.73)
Railroad Gazette, No. 11, September 13, p. 286.

MITCHELL (T. W.). — The growth of the Union Pacific and its financial operations. (11,500 words.)

1907 656 .253
Railroad Gazette, No. 12, September 20, p. 321.

Solenoid signals on the Manhattan Elevated. (800 words & fig.)

1907 621 .335
Railroad Gazette, No. 12, September 20, p. 327.

Electric locomotives of the Pennsylvania Railroad. (900 words & fig.)

1907 388 (.73)
Railroad Gazette, No. 12, September 20, p. 328.

Rapid transit conditions in New York. (3,200 words & fig.)

Railway Age. (Chicago.)

1907 721 .9
Railway Age, No. 1628, August 23, p. 251.

COLPITTS (W. W.). — Design of reinforced concrete structures — Abutments. (2,200 words & fig.)

1907 621 .133.3
Railway Age, No. 1629, August 30, p. 290.

Macklind water tube boilers for locomotives. (500 words & fig.)

1907 625 .233
Railway Age, No. 1630, September 6, p. 339.

Train lighting by electricity. (600 words & fig.)

1907 625 .154
Railway Age, No. 1631, September 13, p. 357.

Modern turntables. (1,200 words & fig.)

1907 625 .142.4
Railway Age, No. 1632, September 20, p. 386.

Kimball concrete-steel ties. (750 words & fig.)

Railway Engineer. (London.)

1907 621 .132.5
Railway Engineer, No. 332, September, p. 271.

0-8-8-0 Mallet compound engine; Erie Railroad. (1,500 words & fig.)

)7 **656** .257
ay Engineer, No. 332, September, p. 276.
mens Bros' “ All electric ”, signalling and inter-
ng plant. (600 words & fig.)

07 **656** .257
ay Engineer, No. 332, September, p. 277.
RREIRA. — Application of electricity to the work-
of railway points and signals. (1,200 words & fig.)

07 **625** .245
ay Engineer, No. 332, September, p. 287.
ivate owners' tank wagons. (1,700 words & fig.)

07 **656** .283
ay Engineer, No. 332, September, p. 296.
ficial reports on recent accidents. (6,500 words & fig.)

ailway and Engineering Review. (Chicago.)

07 **621** .132.5
ay and Engineering Review, No. 33, August 17, p. 721.
ie Mallet compound locomotives. (1,200 words,
le & fig.)

07 **621** .33
ay and Engineering Review, No. 33, August 17, p. 724.
verhead electrical equipment of the N. Y., N. H.
R. R. (3,600 words & fig.)

07 **625** .172
ay and Engineering Review, No. 33, August 17, p. 731.
aintenance of way work. (4,200 words.).

07 **621** .335
ay and Engineering Review, No. 35, August 31, p. 762.
lectric locomotives of the Pennsylvania R. R. (300
ls & fig.)

07 **625** .234
ay and Engineering Review, No. 35, August 31, p. 771.
eating and ventilating of cars. (2,600 words & fig.)

07 **621** .138.3
ay and Engineering Review, No. 36, September 7, p. 785.
ot water boiler washing. (1,700 words.)

07 **621** .331
ay and Engineering Review, No. 37, September 14, p. 801.
lectric power station of the N. Y., N. H. & H. R. R.
os Cob, Conn. (2,600 words & fig.)

1907 **621** .33 (.42)
Railway and Engineering Review, No. 37, September 14, p. 808.

Electrification of the Hammersmith & City Line, Great Western Railway. (1,400 words & fig.)

1907 **656** .256
Railway and Engineering Review, No. 38, September 21, p. 829.

New signal work of the Railroad Supply Co. (800 words & fig.)

Railway Gazette. (London.)

1907 **621** .33
Railway Gazette, No. 9, August 30, p. 205.

McHENRY (E. H.). — Electrification of the New York, New Haven & Hartford. (6,500 words & fig.)

1907 **625** .235
Railway Gazette, No. 11, September 13, p. 258.

A new pressed steel passenger car. (600 words & fig.)

1907 **621** .132.3
Railway Gazette, No. 11, September 13, p. 262.

Pacific locomotive for the Pennsylvania Lines West. (1,100 words & fig.)

1907 **621** .132.8
Railway Gazette, No. 12, September 20, p. 285.

Drewry railway motor cars. (1,300 words & fig.)

1907 **621** .138.3
Railway Gazette, No. 13, September 27, p. 301.

Locomotive boiler inspections in New York State. (2,700 words.)

Railway and Locomotive Engineering. (New York.)

1907 **625** .13
Railway and Locomotive Engineering, September, p. 411.

Subaqueous tunnel at Detroit. (1,500 words & fig.)

1907 **625** .241
Railway and Locomotive Engineering, September, p. 416.

One hundred-and-fifty ton car. (300 words & fig.)

1907 **621** .132.5
Railway and Locomotive Engineering, September, p. 421.

Erie's Mallet articulated compound. (1,400 words & fig.)

1907 **621** .132.8
Railway and Locomotive Engineering, September, p. 427.

Geared locomotive for the C. & O. (550 words & fig.)

Railway Machinery. (New York.)

07 **621** .132.5
way Machinery, September, p. 1.

ie Mallet 16-driver compound locomotives. (1,800 ls & fig.)

Railway Magazine. (London.)

07 **385.** (09.3 (.42)
way Magazine, No. 123, September, p. 177.

e Caledonian Railway's diamond jubilee. (3,500 words .)

07 **625** .232
way Magazine, No. 123, September, p. 262.

e largest private railway coach. (1,200 words & fig.)

Railway Master Mechanic. (Chicago.)

07 **621** .131.1
way Master Mechanic, September, p. 313.

RAWFORD (J. G.). — Locomotive characteristic ves. (1,000 words & fig.)

07 **621** .138.3
way Master Mechanic, September, p. 328.

leaning locomotive machinery. (1,000 words & fig.)

Railway Times. (London.)

07 **656** .212.6
way Times, No. 10, September 7, p. 245.

ew type of Breakdown crane for the Great Indian insula Railway. (450 words & fig.)

07 **621** .132.8
way Times, No. 13, September 28, p. 318.

team motor cars of the Lancashire and Yorkshire way. (400 words & fig.)

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th African Railway Magazine. (Johannesburg.)

07 **625** .61 (09.1 (.68)
th African Railway Magazine, September, p. 429.

TOPIA. — The construction and working of narrow ge railways in South Afrika. (1,600 words & fig.)

Street Railway Journal. (New York.)

1907 **621** .335
Street Railway Journal, No. 8, August 24, p. 278.

Electric locomotives of the New York, New Haven & Hartford Railroad. (4,700 words & fig.)

1907 **621** .331
Street Railway Journal, No. 9, August 31, p. 308.

Cos Cob power station, New York, New Haven & Hartford Railroad Company. (3,500 words & fig.)

1907 **621** .33
Street Railway Journal, No. 12, September 21, p. 412.

Middletown-Berlin electrification of the New York, New Haven & Hartford Railroad Company. (1,300 words & fig.)

1907 **385** .589 (.73)
Street Railway Journal, No. 12, September 21, p. 416.

BRENT (H. K.). — The strike situation in San Francisco. (5,500 words.

Tramway & Railway World. (London.)

1907 **621** .33 (09.1 (.42)
Tramway & Railway World, September, p. 189.

Manchester corporation tramways. (2,400 words, tables & fig.)

1907 **621** .335
Tramway & Railway World, September, p. 204.

Metropolitan Railway electric locomotives for passenger and goods service. (1,500 words & fig.)

In Italian.

Giornale del genio civile. (Roma.)

1907 **385** .15
Giornale del genio civile, agosto, p. 417.

DE VITO (R.). — Le concessioni di ferrovie. (48,000 parole.)

Ingegneria ferroviaria. (Roma.)

1907 **621** .133.3
Ingegneria ferroviaria, nº 16, 16 agosto, p. 262.

LAMAESTRA (A.). — Corrosioni delle caldaie. (2,700 parole & fig.)

907 **625 .216**
gneria ferroviaria, nº 16, 16 agosto, p. 270.

ELL (M.). — Gli agganciamenti automatici all' sizione di Milano. (1,000 parole & fig.)

907 **621 .132.8**
gneria ferroviaria, nº 17, 1º settembre, p. 278.

ARIOTTI (E.). — Studio sull' applicazione dei motori trolio alle automotrici ferroviarie. (5,000 parole.)

907 **625 .142.4**
gneria ferroviaria, nº 17, 1º settembre, p. 283.

ODA (C.). — Traverse per l'armamento e loro oramento colle rotaie. (1,200 parole & fig.)

907 **385 .15**
gneria ferroviaria, nº 17 (supplemento), 14 settembre, p. 1.

e concessioni di ferrovie all' industria privata. 000 parole.)

In Spanish.

Revista de obras públicas. (Madrid.)

1907 **621 .33**
Revista de obras públicas, nº 1667, 5 de septiembre, p. 493.
— — — nº 1668, 12 — p. 506.

Tracción electrica con corriente monofasica. (9,600 palabras, 6 cuadros & fig.)

In Dutch.

Ingenieur. ('s Gravenhage.)

1907 **669. (01**
Ingenieur, nr 34, 24 Augustus, blz. 627.

KLEY (P. D. C.). — Metallographie en practijk. (4,200 woorden & fig.)

Vol. XXI. – No. 12. December, 1907. 12th Year of the English Edition.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[625 .251]

CONTINUOUS BRAKES AND GOODS TRAINS,

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PROFESSOR OF THE UNIVERSITY OF BRUSSELS,
and J. DOYEN,
PRINCIPAL ENGINEER, BELGIAN STATE RAILWAY.

(A contribution to the question of drawing up a programme for making goods-train brake trials)

Fig. 1, p. 1207.

The International Conference of the Union for standardizing railways, which held its third meeting at Berne in May 1907 (¹), decided that it was advisable to appoint an international commission for drawing up a programme of trials of continuous brakes fitted to goods trains. It has seemed to us of interest to examine what questions such a programme should include. With this object in view, we submit the following considerations, which may in the future, we hope, form part of the material with which the future commission will have to deal.

Everyone knows that the braking of long goods trains by continuous brakes involves requirements which already create difficulties in the case of the best existing brakes when fitted to long passenger trains.

These requirements are of two distinct kinds :

A. — *The manageableness of the train* (entering stations and stopping, slacking on the way, going down long inclines, etc.);

B. — *The necessity of making emergency stops* as quickly as possible, without dangerous shock, and as far as possible without breaking any couplings.

(¹) See *Bulletin of the Railway Congress*, No. 8, August 1907, p. 767.

A. — Manageableness of the train

1° *Slacking and ordinary stops.*

In order to be able to slack properly and to stop smoothly, it must be possible for the driver to graduate the action of the brake. Consequently, the first application of the brakes must be a very gentle one, and however gentle it may be, it must be sure to extend from one end to the other of the longest train.

Our experience leads us to believe that we remain within practical limits if we assume that that initial braking is less than one fifth of that produced when the brakes are fully on.

The best brake from this particular point of view will be the one which produces such initial braking on all the cars with the greatest rapidity and certainty.

In making trials with a given brake, it is therefore necessary to ascertain whether a reduction of pressure (1) in the main pipe, equal to one fifth of the reduction required to put the brakes full on, is transmitted from one end to the other of the longest train without material variation. It is also necessary to observe what interval expires till this first application is complete on the last car.

Another important point, as regards regular working and ease of entrance into large stations covered by numerous signals, is the quickness with which the brakes can be taken off. The results given by the best existing brakes allow us, we think, to require that the brakes shall be off within fifteen seconds of the moment the driver has moved the handle to the " brakes off " position, when the brakes have been applied to not more than two thirds of their fullest extent.

2° *Going down inclines.*

From the point of view of going down long inclines, air brakes may be divided into two groups :

1° The first includes the brakes in which the source of energy, the air compressor, remains in direct connection with the brake cylinder during the whole time the brakes are on. The slight leaks in the piston leathers, which are often found even in the case of well-maintained rolling stock, cannot have any serious effect in the case of these brakes, as the air compressor continually makes up for the leakage.

Only plain brakes have this property ; but as with good reason everybody considers automatic action an essential property of a good brake, a plain brake cannot be used unless there is an automatic brake as well; and this leads to complications which would be out of the question with goods rolling stock ;

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(1) In order to simplify matters, we assume that a compressed air brake is under consideration. Vacuum brakes would of course have to be tested in the corresponding manner.

2° The second includes the brakes in which all communication between the compressor and the brake cylinder is cut off while the brakes are being applied.

Such are the differential or two-chamber brakes, of which the Carpenter (compressed air) and the Hardy (vacuum) are examples; and the distributing or one-chamber brakes, of which the Westinghouse is the type.

In these two kinds of brakes, the energy is supplied by the auxiliary reservoir; the supply of air in this cannot be renewed while the brakes are on.

In order to prevent the using up of the source of energy, only two measures can be taken : either make certain that there is absolutely no leakage at the pistons, or else have matters arranged so as to make it possible to charge the auxiliary reservoirs from time to time by taking off the brakes.

The brake trials should therefore prove either that the leakage at the pistons is so small that the pressure in the auxiliary reservoirs does not vary appreciably during the time required for running down the longest inclines, or that the system is such that the auxiliary reservoirs can be recharged with absolute safety. It follows that the recharging operation (during which the brakes must necessarily be off) must be carried out in a time sufficiently short to prevent any undue increase in the velocity.

This point is worth further consideration.

In the case of two-chamber brakes, the time required for recharging the auxiliary reservoirs is always so long that it is not possible to effect it (by the brakes-off method) on gradients which are at all steep. It is therefore necessary that the piston leathers do not leak ; that is a disadvantage which barely compensates for the great adjustability of brakes of this class, although this enables long and steep gradients to be descended at a very uniform velocity. It is besides quite easy to obtain such a uniform speed with a one-chamber brake of the Westinghouse type by replacing the automatic brake on the locomotive by a plain brake. On inclines, the automatic brakes of the tender and the cars is applied not quite strongly enough, and the brake of the locomotive, which can be applied with any desired amount of force, is then used so that the total retardation desired is obtained.

This arrangement gives the adjustability required and moreover makes it very simple to counteract, very effectively, the effect of any leakage through the piston leathers, as with brakes of the Westinghouse type, the auxiliary reservoirs are recharged in a comparatively very short time (1).

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(1) There is moreover a very definite reason why a locomotive should have a plain brake and not an automatic brake. In the case of goods trains composed of loaded wagons, the coefficient of braking of the locomotive and tender (about 60 per cent) is materially greater than that of cars, which may be as low as 20 per cent. Now these conditions may lead to disaster if a coupling is broken, because the front portion of the train is retarded much more than the rear portion, and the latter will consequently catch up the former and a violent collision will result. It is therefore of importance that the locomotive should have a plain brake, which does not act in case of a train-break, but which is applied when the handle of the driver's main valve is placed in the position for an urgent stop. Under these conditions,

In order to ensure proper recharging, we propose the following very simple and practical procedure :

Suppose we have to run down a long incline of 16 per mil at a speed of 16 metres (52 ft. 6 in.) per second. Let us assume the incline in question divided into a series of shorter sections (15 kilometres [9·32 miles] for instance) and at the end of each section let us have a velocity v such that at the moment the brakes are being taken off, the acceleration due to gravity takes a time t to increase this velocity from v to 16 metres (52 ft. 6 in.) per second, t being sufficiently long to allow the auxiliary reservoirs to be recharged fully.

The relation between time and speeds is given by the equation :

$$m\,(16 - v) = \mathrm{F}t.$$

When $m = \dfrac{1{,}000}{g}$, then F equals 16 kilograms minus the rolling resistance per ton, which we will assume is 4 kilograms (8·96 lb. per English ton); *i. e.* F = 16 — 4 = 12 kilograms. We are in fact considering the train on a down gradient of 16 per mil, during a period while the brakes are off, the regulator of the locomotive being closed.

We will take $t = 40$ seconds, experience having shown that on the longest trains the Westinghouse brake fills its reservoirs in less than 40 seconds

The equation given above then becomes :

$$\frac{1{,}000}{g}\,(16 - v) = 12 \times 40,$$

whence $v = 11$ metres (36 ft. 1 in.) per second, or 40 kilometres (24·9 miles) per hour.

That means to say that if the speed is reduced every 15 kilometres (9·32 miles) to 40 kilometres (24·9 miles) per hour, it will be possible to take off the brakes for 40 seconds and fully recharge the auxiliary reservoirs without exceeding the maximum speed specified.

It is clear that this system gives much more security, as regards the using up of the reservoirs, than any in which dependence is placed on having piston leathers which do not leak.

No doubt the objection will be raised that these successive reductions of speed will result in loss of time and that in order to make the run in the required time it will be necessary to increase the authorized maximum speed (16 metres [52 ft. 6 in.] per second). Let us see how much this will have to be increased so that the

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the disadvantages of the plain brake disappears, as it is under the direct control of the driver; and as this brake is wholly on the locomotive, it requires no rubber connection with the tender, and can consequently be made as strong as may be desired. The vacuum brake used in the Arlberg trials satisfied these conditions.

15 kilometres can be covered in $t = \frac{15,000}{16} = 937{\cdot}5$ seconds, and let x be the new maximum speed.

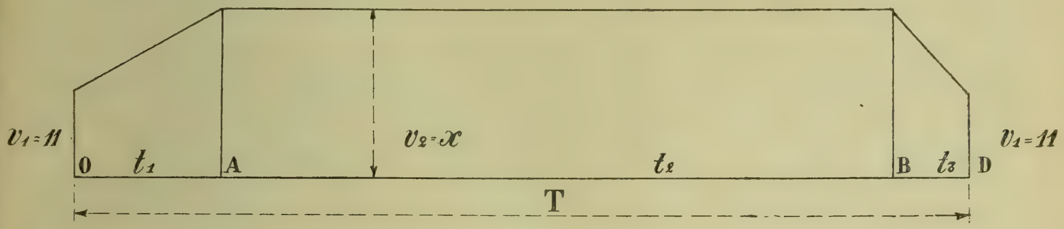

Fig. 1.

The 15 kilometre (9·32 miles) section OD can be divided into three parts :

1° The first OA, speed at entering 11 metres (36 ft. 1 in.) per second; the speed then accelerates till it reaches the maximum x in the time t_1;

2° The second AB, covered at the uniform speed x in the time t_2;

3° The third BD which takes t_3 seconds and during which more powerful braking reduces the speed to 11 metres (36 ft. 1 in.) per second.

Now

$$t_1 + t_2 + t_5 = \mathrm{T} = 937{\cdot}5 \text{ seconds.}$$

We have assumed that

$$t_1 = 40 \text{ seconds,}$$

and we will assume that

$$t_5 = 20 \text{ seconds;}$$

whence it follows that

$$t_2 = 877{\cdot}5 \text{ seconds.}$$

On the other hand

$$\mathrm{OD} = \mathrm{OA} + \mathrm{AB} + \mathrm{BD} = 15,000 \text{ metres (9·32 miles),}$$

and

$$\mathrm{OA} = \frac{11 + x}{2} \times 40 = 20\,x + 220$$

$$\mathrm{AB} = x \times 877{\cdot}5 = 877{\cdot}5\,x$$

$$\mathrm{BD} = \frac{x + 11}{2} \times 20 = 10\,x + 110.$$

Consequently

$$20\,x + 220 + 877.5\,x + 10\,x + 110 = 15,000;$$

and thence we obtain

x = 16·16 metres (53 ft. $^1/_4$ in.) per second or 58 kilometres (36 miles) per hour.

This shows that in the case assumed, the periodic reduction of the speed will only necessitate an increase in the maximum speed of less than half a kilometre (0·31 mile) per hour, a quantity not detected by the ordinary means of measurement. It may therefore be said that the resulting alteration in the service will be nil.

Similar calculations will show that the same system is applicable in case of all the speeds likely to be authorized, even on very steep gradients. Moreover, if there is any fear of too much acceleration, on steep gradients of 25 and 30 per mil, while the brakes are off, the plain brake of the locomotive can always be kept on.

We think that we have shown that the way of working proposed by us is not practically inferior to that used in the case of two-chamber brakes; and that it is decidedly superior to the latter as it insures the proper recharging of the auxiliary reservoirs.

B. — **Emergency stops.**

An emergency stop must evidently be made in the shortest possible time; and it is certain, that in the case of passenger trains, everything must be done to obtain this result, the question of cost being in this case quite secondary in character. The case of goods trains is however different, and we think too high a standard must not be set; this would tend to complicate the brake gear unduly, increase its prime cost and the cost of maintenance, and would tend to delay the time when railway companies would decide to equip their goods trains with continuous brakes.

As an instance of what at present does not appear necessary, we will mention the gear which proportions the coefficient of braking of the wagons to their load. Further on we will show that it is possible, without adopting such expensive devices, to brake goods trains running at 60 kilometres (37·3 miles) per hour quite satisfactorily. As long as the speed of goods trains remains materially lower than that of passenger trains, the former do not require as powerful brakes as the latter.

We think that it would be an excellent practical solution of the question, if the quickest goods trains could be stopped within the same distance as the quickest passenger trains. It is of course evident that, other things being equal, the best brake is the one by which a given train can be stopped in the shortest distance.

1° *Amount of brake-power.*

The amount of brake-power that can be applied is limited by the necessity of avoiding shocks which might be dangerous to the train staff, and, as far as possible, of avoiding the fracture of couplings.

In the case of an emergency stop, the head wagons are braked an appreciable time before the tail wagons, as the brakes on all the cars are not applied simultaneously. The tail wagons drive against the head wagons, the buffers are pressed home and more or less violent shocks result.

This compression of the train has, if we consider the matter only from the point of view of the fracture of couplings, rarely any evil consequences, because the shocks acting forwards first compress the springs, and then act on the buffers driven home and on the underframe; both these parts are very strong. Thus only exceptionally is any rolling stock damaged in this way. But these very strong parts are at the same time very rigid, so that the live forces not taken up by the springs, are annihilated suddenly; all the movable things on the train are shot forwards, and the staff is exposed to serious danger. Shocks acting forwards must certainly be eliminated.

Fractures of couplings, although less dangerous for the employees and less serious, must be avoided as far as possible, as they tend to disturb the working of the traffic a great deal. They are generally due to the following causes :

Several seconds after the handle has been moved in order to apply the brakes, at the time when the buffer springs near the head of the train again expand, the brakes begin to act at the tail. The tail wagons are thus subjected to a double retardation, while the head wagons are sent forwards by the expansion of the springs, and by the reduction in the coefficient of friction depending on the time the brake blocks have been applied (1). The coupling is in this way subjected to sudden stresses which often result in fracture.

It is clear that these effects are the more marked the greater the brake-power applied, and experience shows that with the brakes now used the general coefficient of braking (2) can hardly exceed 40 per cent without risk.

It is advisable, before going any further, to determine what brake-power must be applied in order to satisfy the requirements of a given railway.

It is difficult to solve this question unless a definite instance is taken, and we will therefore select for the purpose the Belgian State Railway, it being understood that the figures we are going to take, are chosen for the purposes of argument only, and to serve as a basis for further discussion.

As regards braking, the most difficult sections on the Belgian systems are :

1° The down gradients from Ans to Liége, which are 4 kilometres (2·5 miles) long; gradients 27 to 32 per mil;

2° The long down gradients of 16 per mil in Luxemburg and in the province of Liége.

As it is a question of an international programme, we will leave out of such consideration such special points as the Liége inclines, as railways which have such exceptional sections should take special and local measures which need not be considered here.

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(1) Douglas Galton's experiments have shown a reduction of about 20 per cent in this coefficient during the first few seconds the brake is on.

(2) We use the term general coefficient of braking for the ratio of the pressure of the blocks on all the wheels of the train to the total weight of the train (tender and locomotive included).

We will accordingly take gradients of 16 per mil as our basis in determining the amount of brake-power required for goods trains on the Belgian State Railway, at the same time noting that the Luxemburg line includes a succession of ascents and of descents, of 16 per mil; consequently, the weight of a train depends on the load the locomotive can haul up such gradients. We will also assume that two thirds of the wagons will be fully equipped with brakes, that the speed will not exceed 60 kilometres (37·3 miles) per hour, and that stops must be made within 600 metres (656 yards). Finally we will assume that all the wagons are fully loaded; this is the most unfavourable case that can occur.

Let :

P = the adhesive weight of the locomotive, in kilograms; this we will assume at the same time to be its total weight;

p = the mean weight of the tender, in kilograms (its weight when half full);

$\frac{P}{n}$ = the tractive effort, in kilograms, which such a locomotive can in practice develop and keep up on an uphill gradient of 16 per mil, going at a speed of 20 kilometres (12·4 miles) per hour. The value of n may be assumed as equal to 10 in the case of the goods locomotives of the Belgian State Railway;

$r + i$ = the resistance of the rolling stock on an ascending gradient of i per mil at a speed of 20 kilometres (12·4 miles) per hour.

Then :

$\frac{P\,(1{,}000)}{n\,(r+i)}$ will be the weight of the rolling stock hauled, and

$P + p + \frac{P\,(1{,}000)}{n\,(r+i)}$ will be the weight of the whole train, locomotive and tender included.

Let us assume that 60 per cent of the locomotive and tender are braked, and let us put x for the braking coefficient of the loaded rolling stock. The total pressure of the brake blocks on the wheels will then be :

$$0{\cdot}6\,(P + p) + \frac{1{,}000\,P}{n\,(r+i)}\,x.$$

If only two thirds of the cars are braked (as we have assumed), the total pressure will become :

$$0{\cdot}6\,(P + p) + \frac{1{,}000\,P}{n\,(r+i)} \times \frac{2}{3} \times x.$$

From this we obtain the general coefficient of braking α :

$$\alpha = \frac{0{\cdot}6\,(P + p) + \frac{1{,}000\,P}{n\,(r+i)} \times \frac{2}{3} \times x}{P + p + \frac{1{,}000\,P}{n\,(r+i)}}.$$

We think that if α is equal to 0·225, this will fully satisfy all requirements; the trials will moreover show how the matter stands.

If in the above equation, we substitute 0·225 for α, 10 for n, 2·5 for r and 16 for i, and if we assume that

$$\frac{p}{P} = \frac{1}{2},$$

we find :

$$x = 0{\cdot}1814;$$

that is to say that goods stock, under the most unfavourable conditions (*i. e.* fully loaded) must have a coefficient of braking of 18·14 per cent. The corresponding coefficient of braking of the empty car depends on the type of the stock.

The newest type of four-wheeled coal truck of the Belgian State Railway has a tare of 8 metric tons (17,640 lb.) and can carry a load of 21 metric tons (46,300 lb.).

The pressure of the blocks on the wheels must therefore be equal to

$$(8{,}000 + 21{,}000) \times 0{\cdot}1814 = 5{,}260 \text{ kilograms } (11{,}600 \text{ lb.}),$$

and this corresponds to

$$\frac{5{,}260}{8{,}000} = 66 \text{ per cent of the tare.}$$

As this is a very unfavourable type of wagon from the point of view of braking, we think that the conditions will be excellent if the available brake pressure corresponds to 65 per cent of the tare of the goods stock.

A preliminary series of trials should show whether this 65 per cent of the tare is sufficient, that is to say, whether the driver keeps his train under full control on down gradients of 16 per mil, both as regards uniform running and urgency stops, even if all the wagons are fully loaded and brakes are only used on two thirds of them.

This series of trials is very important from the point of view of safety, but the true difficulties involved in the use of brakes on goods trains, will not show themselves in this series.

A brake is subjected to the most severe treatment in the case of long trains consisting of empty wagons, and the results will depend not only on the class of brake tried, but also on the number of wagons, on the brake pressure, on the construction of the drawgear and buffing gear, and on the amount of play at the couplings. It is therefore of importance to consider how the trials should be arranged to meet these difficult cases.

2° *Number of wagons and brake pressure.*

The number of wagons a train can be composed of depends directly on the general coefficient of braking. We have shown above that a considerable brake pressure (65 per cent of the tare) is necessary in order that a loaded wagon may have a sufficiently large coefficient of braking. This necessity may result in a high general coefficient of braking in some cases, for instance when the train is composed of wagons all or nearly all equipped with brakes.

We do not disregard the fact that all the systems of brakes allow the number of braked wagons to be reduced by closing the cut-out valve af a certain number of them. But that is a proceeding hardly permissible in ordinary practice, and which we even consider dangerous. The employees already have to see that there are enough brakes. More can hardly be expected of them and it will be futile to expect them to consider an excess of braking; for it will be impossible or at least very difficult to make them understand that such may be dangerous. It is essential to avoid frequent opening and closing of cut-out valves, or it will happen that brakes will be found cut out just when there is greatest need for them. We do not think it advisable to lay down the principle that if the employees find when the brakes are being tested before the start, that the brake blocks of a wagon are not pressed against the wheels, they then should have to consider whether the brake in question is a faulty brake or cut out intentionally.

It is therefore in our opinion advisable to accept the strong brake pressures which may happen to result from the composition of trains, even if it consequently becomes necessary to reduce the total number of wagons. We have no hesitation in stating that we prefer a brake suffering to give a pressure of 65 per cent of the total weight of a train of 50 wagons to another giving excellent emergency stops with 75 wagons, but giving a presure not exceeding 45 per cent.

Trials should then first be made on trains of 50 empty wagons having a general coefficient of braking of 60 to 65 per cent; then it should be tried whether the system allows the number of wagons to be increased.

We may incidentally remark that compositions so excessive from the point of view of braking, will occur but rarely in practice. Too much regard must not therefore be paid to the fractures of couplings which will result, as the cases are quite exceptional. Moreover, the fracture of couplings has as immediate result only damage to stock, and it will also be possible to remedy this by making the drawgear stronger.

But it is of importance to ascertain with care that no shocks in a forward direction are produced, as such are dangerous to anybody on the train.

3° *Class of coupling.*

As the German continuous drawbar system is the one most generally used on European goods stock, it would be desirable to find a brake which would suit that system and the preliminary trials should have this object in view.

The numerous brake trials we have made have however led us to believe that it is very desirable, if not absolutely necessary, to increase the dynamic resistance of the drawgear by adding friction gear to the drawbar. This comparatively inexpensive alteration is moreover amply justified by the numerous fractures which already occur.

It would thus be very useful to make trials in order to determine whether the adoption of any system of friction drawgear would not, as we think, make it possible to increase either the brake power or the number of wagons a train can consist of.

4° *Play in the couplings.*

The play between the buffers is of material importance as regards shocks in a forward direction; other things being equal, the results obtained with a given brake can be very different according to the magnitude of that play.

If with a given brake dangerous shocks in a forward direction result, two remedies can be applied to reduce them :

1° The couplings are drawn up as tightly as possible.

This measure tending to complicate the operation of putting together a train and taking it apart, we propose to begin the trials by leaving a minimum play of 5 centimetres (2 inches) between the buffers, this amount to be increased or reduced according to the results obtained ;

2° The buffers are fitted with friction gear.

This would be a very desirable solution as regards not only the braking, but also the shunting operations in marshalling yards. As it however involves considerable expense, we do not think that it is to be insisted on.

5° *Wagons with plain pipes only.*

Some brake systems require the wagons with plain pipe to be equipped with accelerators to ensure the transmission of the quick action, from the one end of the train to the other, in case of emergency stops.

Other systems do not require this costly accessory, which in no way increases the power of the brakes.

It should therefore be ascertained with the brake tried, to what extent groups of wagons with plain pipes only can be inserted in the train.

6° *Wagons without pipes.*

During the transition period it will be necessary to place a certain number of wagons which have no pipes at the tails of trains equipped with the continuous brake. The trials must show that the brake tried is satisfactory under these conditions. It seems desirable, from the point of view of operating the traffic, that it should be possible to place at the tail a number of non-braked wagons equal to one third of the total number of wagons, and to make with such a train emergency stops without producing violent shocks in a forward direction.

7° *Mixed trains.*

Finally, it must be proved that the brakes which are being tested can be used simultaneously with the brakes actually used on passenger stock. The trains used for this series of tests should be the heaviest specified in the mobilization schemes.

C. — **Summary and conclusions.**

We will summarize the preceding note by stating what points should be considered when making trials of goods train brakes.

The *manageableness* of the brake and the sort of *emergency stop* it can produce must be examined.

As regards its *manageableness :*

1° It must be ascertained that the initial application of the brakes is transmitted without material alteration through the whole train, no matter what its length may be;

2° The time necessary for completing this initial braking on the last car must be determined. The shorter this time, the better the brake from this particular point of view;

3° We think that this initial braking may correspond to one fifth of the retarding effect produced if the brakes are full on. If a gentler application of the brake can be made, this is naturally in favour of its manageableness;

4° As the possibility of taking the brakes off quickly is an important factor in its manageableness, the more quickly this can be done, the better. We think that it may be specified that it should be possible to take the brakes quite off in 15 seconds if they have been applied two thirds of quite full on;

5° In descending inclines, it must be ascertained :

In the case of two-chamber brakes : that the auxiliary reservoirs remain quite tight during the time required for the longest descent in question;

In the case of one-chamber brakes : that it is possible to recharge the reservoirs (by taking off the brakes) on the steepest gradients in question without the speed exceeding the limits which are specified.

As regards *emergency stops*, the following points require the special consideration of the experimenters :

1° *Brake-power.* — Is the brake-power provided sufficiently large to enable the driver to keep complete control, under all circumstances, of a train consisting of loaded wagons two thirds of which only are braked?

2° *Number of wagons.* — Can a train of fifty empty wagons be braked without risk, all the wagons being braked? Can this number be increased to beyond fifty?

3° Is it advisable to fit the drawbars with friction gear?

4° Can the *play between the buffers* be fixed at 5 centimetres (2 inches)? Can this amount be increased or should it be diminished?

5° How many wagons, *with plain pipes only*, can be inserted, in one group, in a train without interfering with the proper transmission of the quick action?

6° Can emergency stops be made with a certain number of *wagons without pipes*, fixed to the tail of the train? The initial number to be a small one (two or three wagons), and then gradually increased.

7° Can the brake which is being tested be coupled up without difficulty with the kind of brake used on passenger trains?

[656 .212]

THE NEW SHUNTING YARD AT WATH, IN ENGLAND,

By Mr. FRAHM, of Berlin.

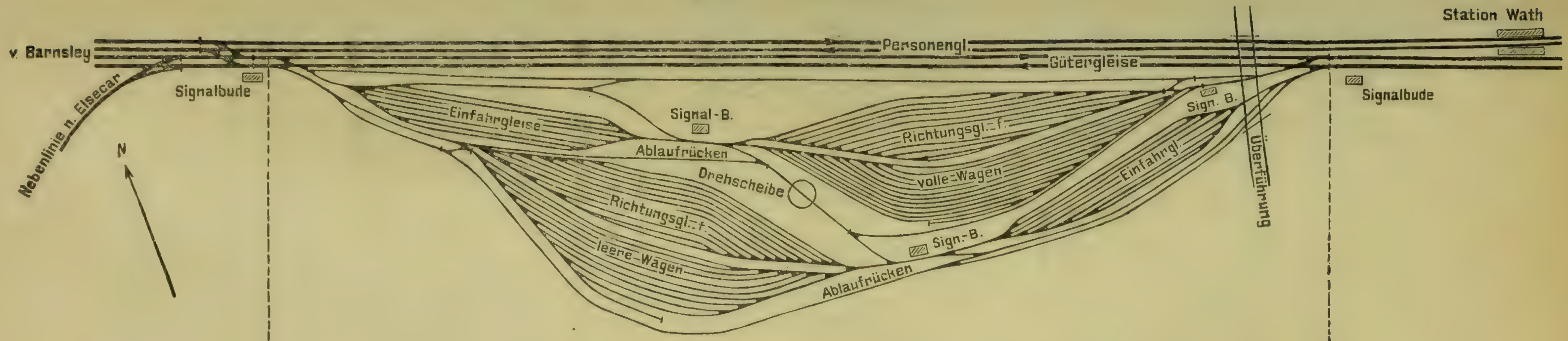
Figs. 1 and 2, p. 1217.

(*Zentralblatt der Bauverwaltung.*)

On English railways, many short through goods trains are run, which go direct from terminal to terminal, and consequently require no re-arrangement at any shunting yard en route. The provision made for shunting operations is generally of a simple character and is chiefly used for making up the trains at the despatching station, and for shunting the separate wagons to their respective sidings at the receiving station. In the case of the coal traffic, which forms a large fraction of the total goods traffic, the trains are generally already made up according to direction at the coal-pit sidings. To arrange them according to station is seldom required, so that special sorting sidings near the coal-pit sidings are unnecessary. Of late however, the tendency has been to have heavier through trains, and to carry out the sorting and shunting operations at given spots, so as to reduce cost of haulage and of shunting operations, and this necessitates the construction of larger sorting and shunting yards. Several railways are accordingly planning new shunting yards. The existing shunting yards are mostly built with single inclines; such inclines are as a rule preferred, when local conditions facilitate their construction, to double inclines. In this connection, it is an advantage that in England all goods wagons are fitted with hand lever brakes, which make powerful braking possible. But taking it altogether, it is not only the conviction that yards with a single incline are superior to double inclines which induces English engineers to construct them, but a certain feeling of superiority, that it is unnecessary to take any notice of improvements made in other countries, also comes into play. In recent times however, more attention is given to double inclines; the example of America may have had some effect in this direction, whereas the model installations in Germany have hardly been heard of.

The new shunting yard which the Great Central is now building at Wath (on the four-track Barnsley-Doncaster line) is intended to deal with a large number of coal trains from coal-pits in the Midlands, particularly in South Yorkshire, and also for dealing with the empty trains going to the pits. The yard is arranged on the double-

Fig. 1. — General plan.



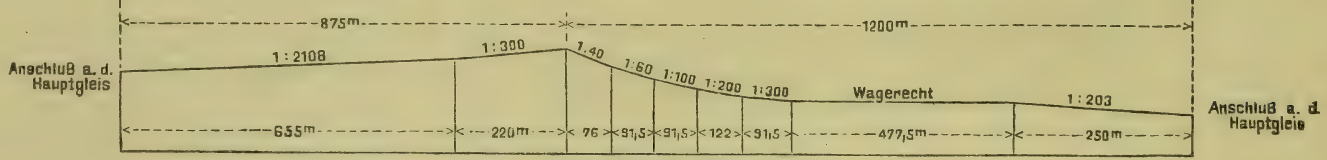


Fig. 2. — Profile.

Explanation of German terms of the figure 1 : V. = From. — N. = To. — Nebenlinie = Branch line. — Einfahrgleise = Reception sidings. — Personengl. = Passenger train lines. — Gütergleise = Goods train lines. — Signalbude = Signal box. — Ablaufrücken = Saddle-back. — Drehscheibe = Turn-table. — Richtungsgl. = Sorting sidings. — Volle Wagen = Loaded wagons. — Leere Wagen = Empty wagons.

Explanation of German terms of the figure 2 : Anschluss a. d. Hauptgleis = Junction with main line. — Wagerecht = Level. — Ueberführung = Bridge over lines.

track system, that is to say, that a separate set of reception and sorting sidings is provided for each direction of running; the sorting sidings also serve as departure lines for the completed trains. The trains will be arranged for four directions; this makes 57 kilometres (35·4 miles) of track altogether necessary. The yard will be over 2 kilometres (1 $^1/_4$ mile) long and cover an area of 40 hectares (98 acres); it will be possible to deal with 5,000 wagons in twenty-four hours. As shown in the plan figure 1, two lines branch off, at the same height, from the two main goods lines at two points about 2 kilometres (1 $^1/_4$ mile) apart; one serves for the entrance of unsorted trains into the first set of sidings (reception sidings) and the other for the departure of sorted trains from the second set of sidings (sorting sidings). At each end of the yard, is a group of eight reception sidings, ascending to a saddle-back. At each end, a separate connecting track, running round outside the grid, is provided; inside the yard proper, there are also several junction tracks. A turn-table is on the junction line between the two inclines; near it two dead-end sidings branch off with cleaning pits 23 metres (75 ft. 6 in.) long. As shown in the profile (fig. 2) the west reception sidings for loaded wagons and their junction lines have successive rising gradients of 1 : 2,108 and 1 : 300, followed by a falling gradient of 1 : 40. Then come the sorting sidings with gradients of 1 : 60, 1 : 100, 1 : 200 and 1 : 300 followed by a level section; the departure lines have a fall of 1 : 203. The group of sidings for west bound wagons is arranged similarly. The east entrance lines and reception sidings have an ascending gradient of 1 : 109; then comes the incline with a falling gradient of 1 : 40, and the sorting sidings with gradients of 1 : 60, 1 : 100, 1 : 200 and 1 : 300, followed by a level section and an ascent of 1 : 300. The west departure lines, which join the main lines, have an ascending gradient of 1 : 125. Thus whereas the loaded trains leave on lines with a falling gradient of 1 : 203, the empty trains have to leave on lines having ascents of 1 : 300 and 1 : 125, which however seems admissible as the trains are lighter.

Short curve-leads and curves of small radius are used so as to utilize as much room for sidings as possible. The switches are operated by compressed air, controlled electrically. The completion of each switching operation is automatically shown in the signal cabin.

Waiting rooms and sleeping accommodation are provided for the locomotive and train crews and sundry other officials. At present, a large number of shunting locomotives are at work at the different coal-pit sidings shunting full and empty wagons. In future most of these shunting operations will no longer be carried out; the full trains are to be brought, no matter what the order of the wagons may be, to Wath sorting yard and are there to be sorted and marshalled for the four directions concerned; the empty trains are to be taken to the coal-pit sidings with the wagons arranged as far as possible in proper order.

The North Eastern Railway, which has the heaviest goods traffic in England, has for some years been considering the question of constructing a large shunting yard, with double incline, at Northallerton. The plans have already been made, but their execution has been postponed for the time being.

[656 .211]

THE NEW STATION AT STUTTGART,

By B-m.

Figs. 1 to 4, p. 1220 to 1224.

(Zentralblatt der Bauverwaltung.)

The government has submitted to the Wurtemberg Landtag a proposal for the thorough alteration of the tracks and sidings at Stuttgart; and we are consequently within a measurable distance of the solution of a question which has been under consideration for a long time, and which has formed one of the most important and difficult problems in connection with the improvement of the German railways.

As the general plan shows (fig. 3) all the lines to Stuttgart at present enter a large terminus station which is well inside the city. The lines from Feuerbach and Böblingen as well as the goods connections with Kannstatt, in doing this, go round some large cavalry barracks which are in front of the station, and round a sugar refinery (see fig. 4). This cramping of the station prevented the construction of sufficient sidings and had led to the transfer of the locomotive sheds and their appurtenances to the very distant Nord station; and both these circumstances materially interfered with the proper organization of the service.

As some of the lines running into Stuttgart are really used as through lines, it was necessary, when considering what alterations and additions should be made in the station in order to meet the continually growing requirements of the traffic, to examine whether it would not be advisable to replace the terminus station by a through station. But careful consideration of all the factors involved, led to an answer in the negative, for as the city is located in a valley surrounded by high mountains, it was not possible to design a through station which would give a satisfactory solution. There were two places in which such a station might have been built. It could have been located about 2·5 to 3 kilometres (1·5 to 1·8 miles) to the north of the present chief passenger station, and this would have been very inconvenient for the inhabitants of the city and for all the local traffic which far exceeds the through traffic in volume (through passengers are in number only equal to 5·7 per cent of the total number of passengers). Or else, in order to avoid this disadvantage, the station could have been built on the spaces occupied by the old goods station and the cavalry barracks; but then its connection with the lines *viâ* Feuerbach to Ludwigsburg and Calw and to Böblingen could only have been effected by means of a sharp curve in a tunnel extending right to the passenger station, and this would have

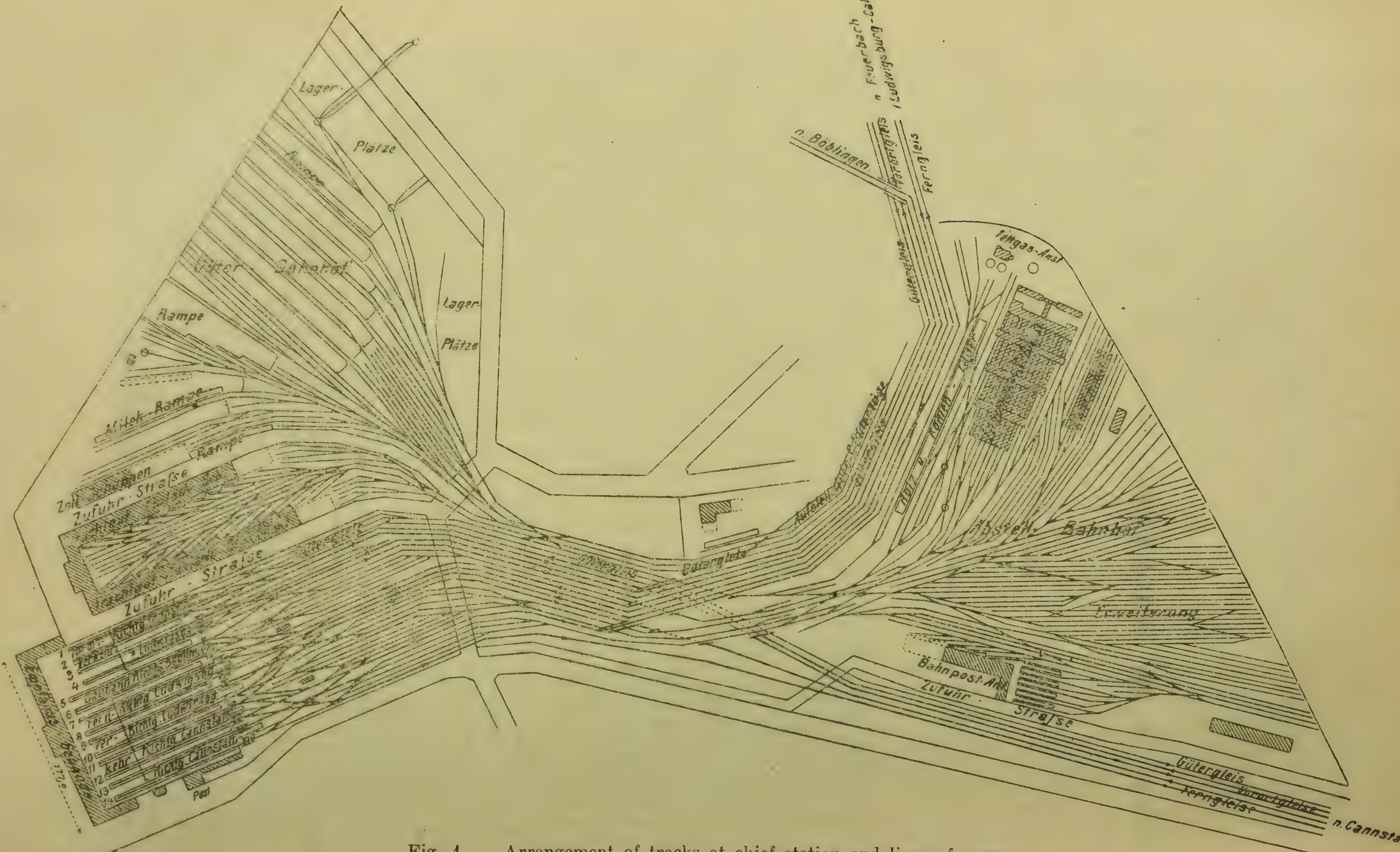


Fig. 1. — Arrangement of tracks at chief station and lines of access.

Explanation of German terms : Abstell-Bahnhof = Train yard. — Ausstellgleis f. Güterzüge = Marshalling siding for goods trains. — Bahnpost-Anl. = Railway post-office building. — Eilgut = Quick freight. — Erweiterung = Extension. — Fernverkehr = Main line traffic. — Fettgas-Aust. = Gas works. — Frachtgut Einlade Sch. = Sheds for slow freight to be loaded up. — Frachtgut Auslade Sch. = Sheds for unloaded slow fleight. — Güter-Bahnhof = Goods yard. — Holz- u. Kohlen-Lager = Wood and coal store. — Lagerplätze = Storage space. — **Milch-Rampe = Milk ramp.** — Post = Post office. — Rampe = Ramp. — Vorortgleise = Suburban tracks. — **Vorort-Verkehr = Suburban traffic.** — **Zoll-Schuppen**

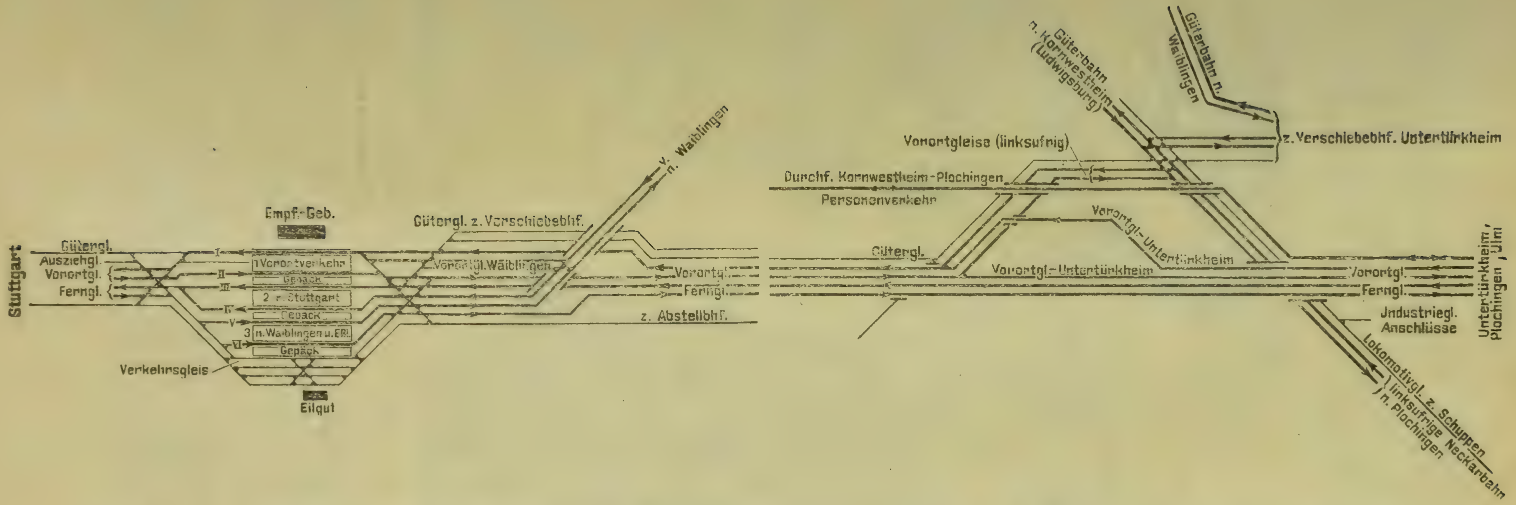


Fig. 2. — Arrangement of tracks at the new passenger station Kannstatt, with connection to the railway on the left bank of the Neckar.

Explanation of German terms : Ausziehgl. = Draw-out siding. — Empf.-Geb. = Station building. — Gepäck = Luggage. — Ferngl. = Main line. — Güterbahn n. = Goods line to. — Gütergl. = Goods line. — Gütergl. z. Verschiebebhf. = Goods line to shunting yard. — Industriegl. Auschlüsse = Branches to industrial sidings. — (Linksufrig) = (On the left bank of the river). — Linksufrige Neckarbahn = Railway on left bank of Neckar. — Lokomotivgl. z. Schuppen = Line to locomotive sheds· — n. = To. — Verkehrsgleis = Through track. — Vorortgl. = Suburban line. — Vorortverkehr = Suburban traffic. — z. Abstellbhf. = To train yard. — z. Verschiebebhf. Untertürkheim = To Untertürkheim shunting yard.

much interfered with the development of the sidings and the organization of the service in the south-west section of the station. It was therefore decided to retain the form of a terminus station for the chief station, but the condition was laid down that all level crossings in the chief station were to be avoided, at all events as far as the very important routes for the through traffic Feuerbach Stuttgart-Kannstatt were concerned.

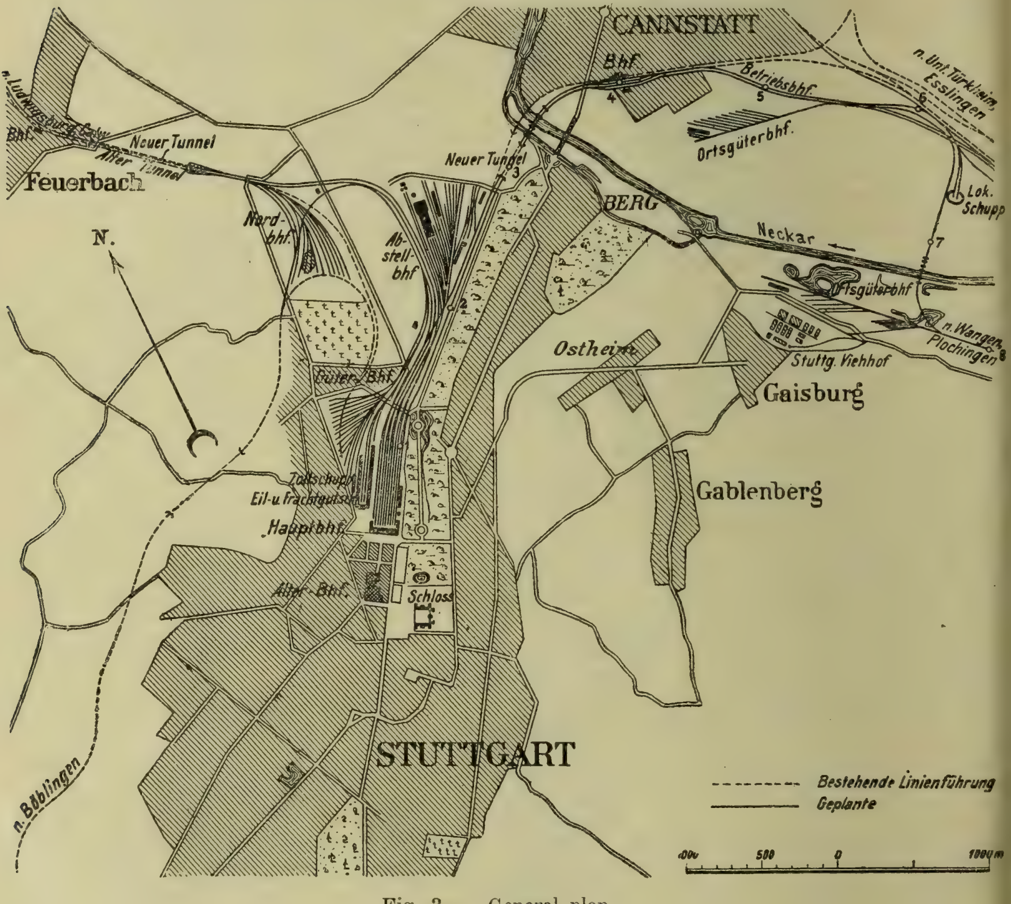


Fig. 3. — General plan.

Explanation of German terms : Abstellbhf. = Train depot. — Alter-Bhf. = Old station. — Alter Tunnel = Old tunnel. — Bestehende Linienführung = Existing lines. — Bhf. = Station. — Eil-u. Frachtgutsch. = Goods and parcels sheds. — Geplante = Proposed. — Güterbhf. = Goods yard. — Hauptbhf. = Chief station. — Lok. Schupp. = Locomotive sheds. — n. = To. — Neuer Tunnel = New tunnel. — Nordbhf. = Nord station. — Ortsgüterbhf. = Local goods yard. — Schloss = Castle. — Viehhof = Cattle yard. — Zollschupp = Custom house.

There were two possible positions for the new chief passenger station. It could be placed in the Schloss-Strasse, where the present station is (fig. 4), or could be placed further north, in the Schiller-Strasse. In the first case, a greater length was available for the sidings, moreover the existing line to Böblingen could be retained as well as the locomotive sheds at the Nord station. But the retention of these old sheds would have left untouched the disadvantages resulting, from the point of view of the organization of the service, owing to their distance from the station itself; moreover, it would not have been possible to utilize the space now occupied by the sheds for the urgently required extension of the installations for dealing with the local goods traffic at Nord station. To transfer the locomotive sheds to the carriage depot proper, would have necessitated the purchase of a large piece of land; and on the other hand, no part of the land now occupied by the railway would have become available for other purposes As moreover it was very much desired to utilize the land on which the old station stands between Schloss-Strasse and Schiller-Strasse for the erection of private houses, it was decided to have the frontage of the new station in Schiller-Strasse, and to build an entirely new station, capable of satisfying all requirements.

Figure 1 shows a diagramatic sketch of the new central station, with the various lines running into it. Whereas in the old station only four platforms and four platform tracks were available, there will be fourteen platform tracks in the new station, with seven passenger platforms and eight luggage platforms. Owing to the great development of the local traffic, it was decided to supplement the sections to Ludwigsburg and Untertürkheim by laying two new tracks for the local service alongside the express tracks, in other words, to make these four-track sections. On the Ludwigsburg section, it is possible to lay the second pair of track alongside the existing pair, without interfering with the roadbed of the latter; but between Stuttgart and Kannstatt it is necessary to build an entirely new four-track section, with a new tunnel under the Rosenstein park and a new bridge over the Neckar. The old bridge and the old tunnel are to be utilized for special goods lines connecting the Stuttgart goods station with Kannstatt and the adjoining shunting and sorting station Untertürkheim.

The application of this principle of separate tracks for main line and for local traffic also extends to the station, where separate sidings and platforms are provided for the two services; the four western tracks, Nos. 1 to 4, with two intermediate platforms, are exclusively for local traffic; the eight eastern tracks, Nos. 7 to 14, with four intermediate platforms, are exclusively for main line traffic. The two tracks in between, Nos. 5 and 6, with one intermediate platform, are for the Böblingen traffic; here main line and local traffic are not kept separate.

As regards the plan of the tracks, provision has been made, as already stated, that the through trains of the Ludwigsburg-Stuttgart-Kannstatt services can enter and leave the station without crossing at the same level any routes of trains going in an opposite direction; in order to effect this, the through track from Feuerbach, before it reaches the station, goes under the track to Feuerbach, so that the trains go on the left hand track while on this crossing below. In addition, the through track from Kannstatt goes, before it reaches the station, under the through track from Feuerbach. Sidings Nos. 7 and 14 are thus chiefly to be used for the through traffic of that section.

Moreover, in order to avoid level crossings, the suburban tracks from Kannstatt cross below the tracks of the Feuerbach and Böblingen sections.

The platform sidings are in direct connection with numerous sidings which are primarily intended for the accommodation of trains which are ready for use, and of trains which have to be kept at the chief station for a short time without any material alteration in

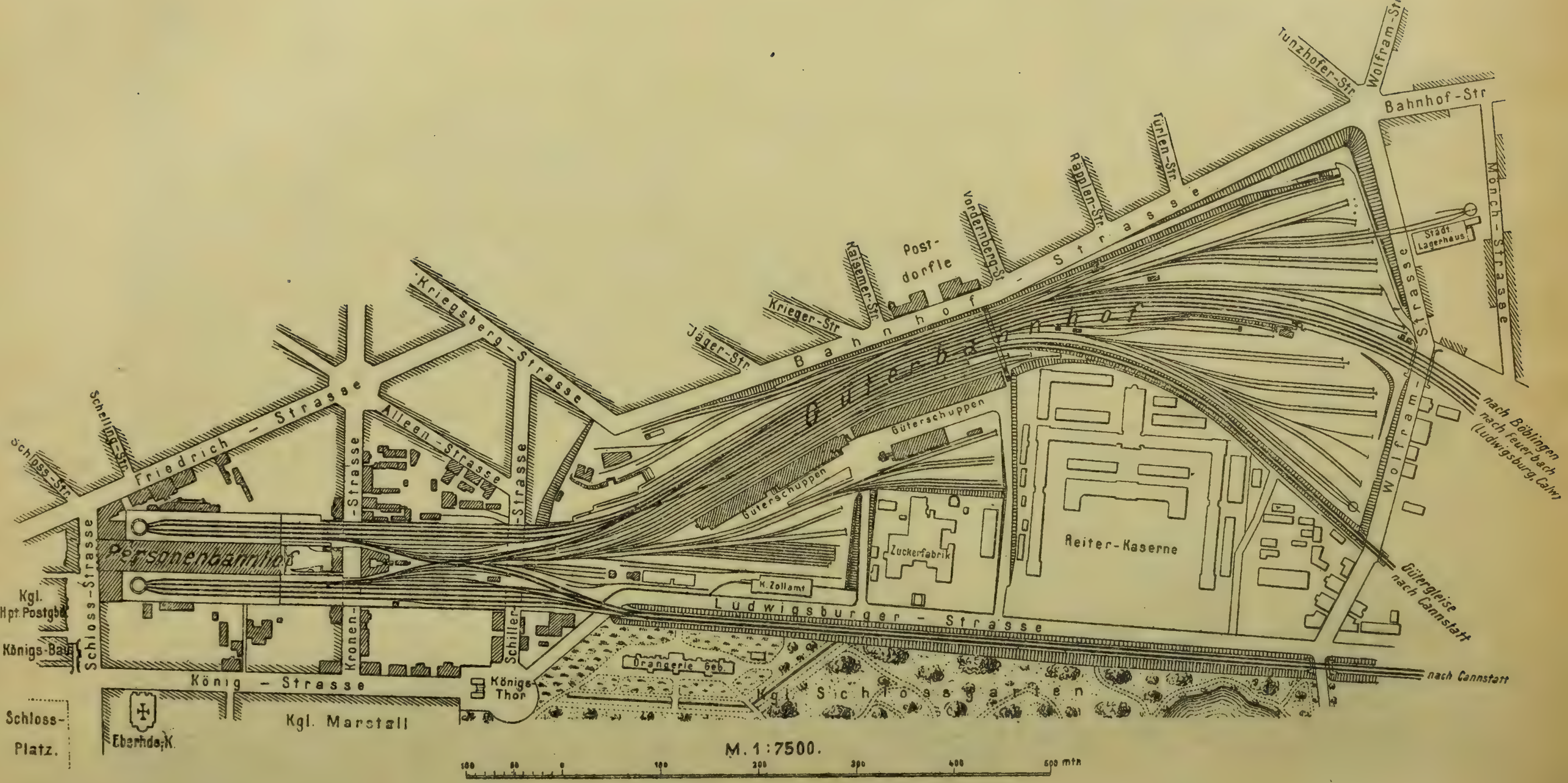


Fig. 4. — The chief station, Stuttgarts, in 1904.

Explanation of German terms : Güterbahnhof = Goods yard. — Gütergleise nach = Goods tracks to. — Güterschuppen = Goods sheds. — Kgl. Hpt. Postgb. = General post office. K. Zollamt = Custom house. — Nach = To. — Personenbahnhof = Passenger station. — Reiter-Kaserne = Cavalry barracks. — Zuckerfabrik = Sugar refinery.

their composition; further out, there is an extensive carriage and locomotive depot with sorting and marshalling sidings and all the usual installations for trains which are to be kept there for a long time. Next the carriage depot, are a number of sidings and installations for dealing with the mails.

In connecting the station sidings with the depot sidings, great care was taken to avoid crossings with the routes of entering or departing trains; and the same applies to the relations between the central goods stations, sidings and the main line tracks.

Besides the chief Stuttgart station, the Kannstatt station is also to be entirely reconstructed; here, the existing lines to Waiblingen and Plochingen diverge and a new line will go along the left bank of the Neckar to Plochingen. Figure 2 is a diagram of the arrangement proposed. Kannstatt station is in direct connection with the important sorting station of Untertürkheim, from which special goods tracks go to the Waiblingen section and to the Kornwestheim shunting station, which is between Stuttgart and Ludwigsburg, and from which the trains go to the Stuttgart central goods station and the Nord station. We have not sufficient room available to enable us to enter into the particulars of the extensions of these sorting stations, of the alterations in the goods lines and of the construction of additional goods stations.

The total cost of all these alterations and improvements, including the construction of the line on the left bank of the Neckar, is estimated at 94,500,000 marks (£4,725,000); 15,700,000 marks (£785,000) being for the new line and 51,650,000 marks (£2,582,500) being for the alterations at Stuttgart itself, from the passenger station to the ends of the tunnels for the Kannstatt and Feuerbach sections. This latter figure is arrived at by reducing the amount of 75,050,000 marks (£3,752,500), for purchase of land and cost of construction, by 23,400,000 marks (£1,170,000) which is expected to be realized.

The whole project is designed in a liberal and methodical spirit, and is worth special attention. When the scheme has been carried out, Stuttgart will be in the possession of an installation which will enable the service to be organized in an eminently satisfactory and safe way.

[621 .135.2]

TESTS OF STAYBOLTS AND STAYBOLT IRON (1),

By E. L. HANCOCK,

ASSISTANT PROFESSOR OF APPLIED MECHANICS, PURDUE UNIVERSITY.

Figs. 1 to 6, pp. 1227 and 1228.

(*Railway Age.*)

During the past year a series of tests of staybolts and staybolt iron has been carried on under the direction of the writer in the laboratory for testing materials of Purdue University. Inasmuch as this subject is now occupying the attention of one of the committees of this society, it was thought that the results of the tests made would be of interest and value. The Investigation, which was quite independent of the work of the committee, was divided into two parts : 1° An investigation of the effect of varying the length and tensional stress of hollow staybolts upon their resistance to vibration; 2° an investigation of the relative strength of solid and hollow staybolt iron of the same grade.

The staybolt iron, both solid and hollow, was one inch in diameter, the hollow having a hole in the center 0·38 inch in diameter. The bars were purchased on the market of a prominent manufacturer, who was requested to furnish uniform material. The order called for solid and hollow staybolt material of the same grade. In furnishing the material, the manufacturer claimed that the solid and hollow bars were of exactly the same material, the hollow bars being produced by rolling the solid bars, increasing the strength and flexibility of the material and making it more uniform in structure. Direct tension tests showed the material to have the following physical properties :

	Yield point.	Maximum strength.	Per cent of elongation.	Per cent of contraction.
Hollow material	31,700 lb.	44,700 lb.	27 (in 8 inches).	34
Solid material	33,160 lb.	44,600 lb.	25 (in 6 inches).	38

An Olsen vibratory machine was used in making the test. This machine is so constructed that one end of the staybolt may be rigidly clamped, while the other end is caused to move in a

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(1) Paper presented before the American Society for Testing Materials at Atlantic City, N. J., June 21, 1907.

Figs. 1 to 6. — *Tests of staybolts.*

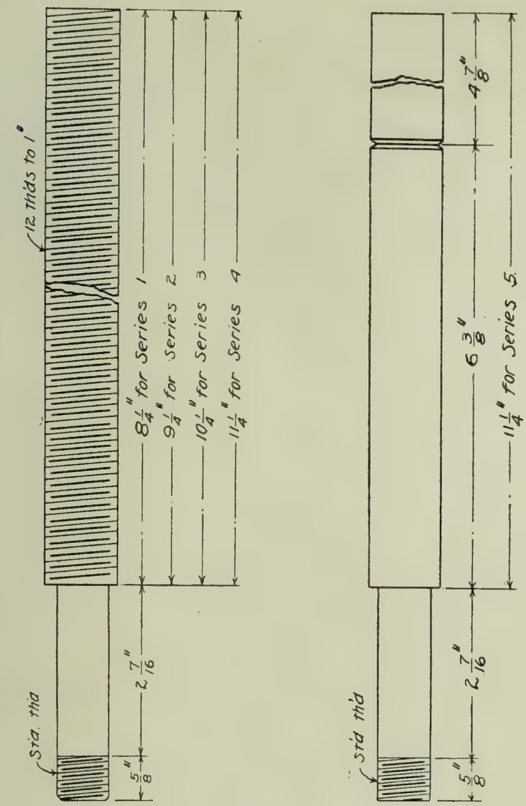

Fig. 1.

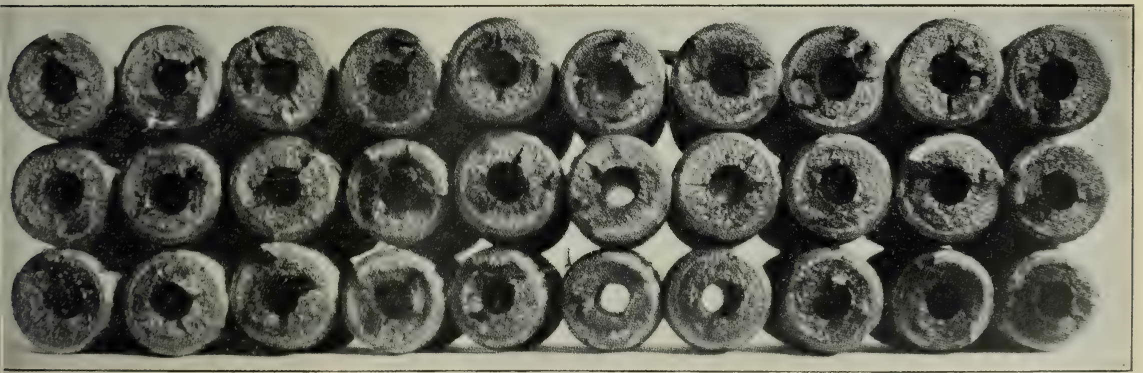

Fig. 2.

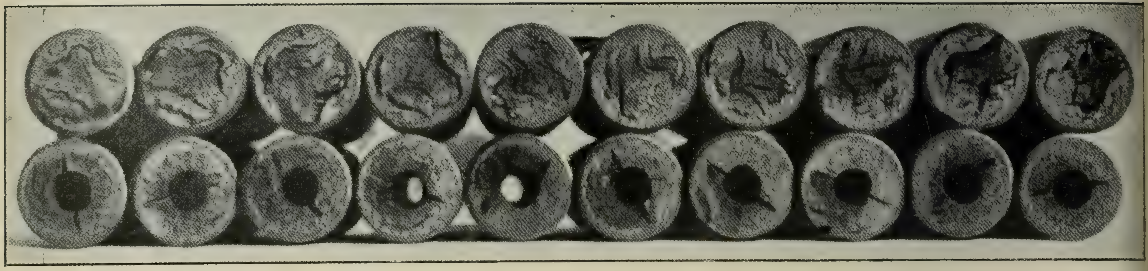

Fig. 3.

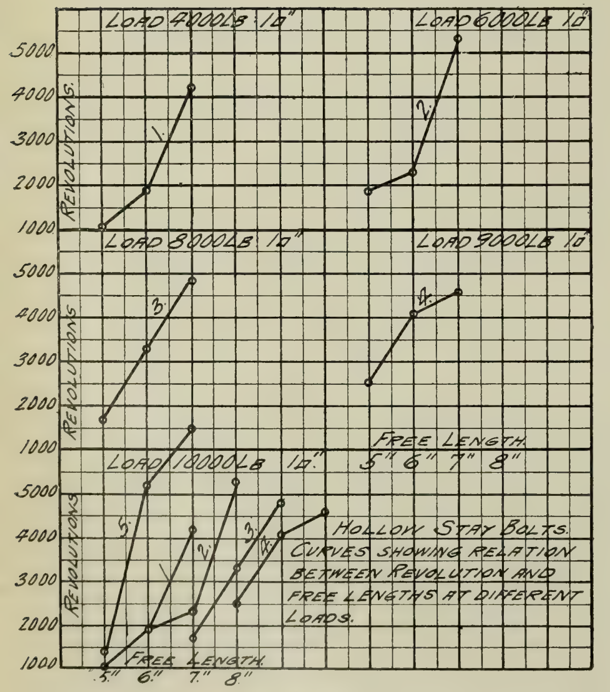

Fig. 4.

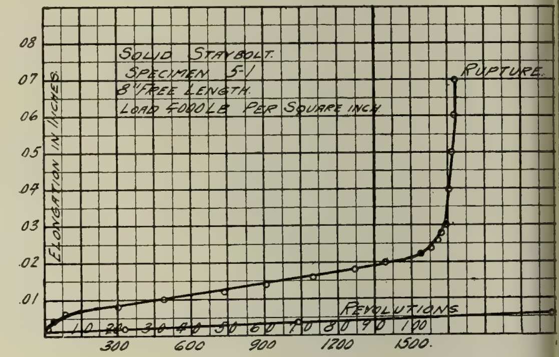

Fig. 5.

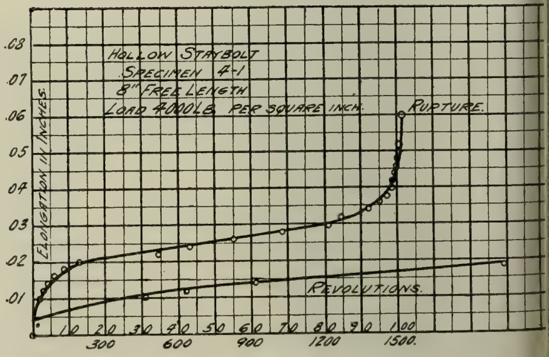

Fig. 6.

circle of desired radius. Provision is also made for the application of desired tensional loads, making it possible to vibrate the material while under tension. The machine is familiar to most engineers and needs no further description here. The test specimens were prepared in accordance with diagram, Figure 1. About 5 inches was allowed at one end for clamping in the machine, and about three inches at the other for the fitting on of the ball, by means of which vibration was possible. The length of the staybolt was given as the distance from the lower end of the clamp to the center of the ball. Three groups of hollow staybolts, having lengths of 5, 6 and 7 inches, respectively, were prepared; these were threaded with standard staybolt dies, 12 threads to the inch. They were tested in such a way that one end of the bolt vibrated in a circle 1/4 inch in diameter, at the rate of 120 revolutions per minute. In each group specimens 1, 2, 3, 4 and 5 were vibrated under tensional stresses of 4,000, 6,000, 8,000, 9,000 and 10,000 pounds per square inch, respectively. Two other groups, one of hollow and one of solid staybolt iron, were prepared. These pieces, which were all 8 inches long, were left unthreaded, but were grooved (*see* fig. 1) just at the lower edge of the clamp. They were vibrated through the same distance at those just described and at the same speed, the tensile stresses varying from 4,000 to 10,000 pounds per square inch in each case. While the tests were being made observations were made of the number of revolutions for certain increments of elongation, as indicated by the machine. These elongations, while not the actual elongations, serve to show something of the behavior of the material while under these tests.

The sections of the broken specimens are shown in the photographs, Figures 2 and 3. Figure 2 shows the fractured ends of the threaded bolts of series 1, 2 and 3. The fact that the load and length varied in the different specimens is not apparent in the fractures. All have a characteristic crack, extending on each side of the center toward the outside. Figure 3 shows the fractured ends of the unthreaded bolts of series 4 and 5. The specimens in these series were grooved at the lower edge of the clamp. An examination of the fractures shows the same single crack, extending from the center outward, in the hollow bolts. The fibers of the solid bolts do not seem to be so well united. If the materials were originally the same, the process of making the material hollow seems to have united the fibers, so that separation takes place only in one plane. There seems to be no change in the fracture due to change in tensile load and the fractures of the threaded bolts do not differ noticeably from those of the grooved bolts.

Table I gives the numerical results of all tests made. It is seen that the percentage of contraction of area was greater for the threaded bolts than for those that were not threaded and greater for the unthreaded hollow than for the solid. The per cent of elongation, of the original length, is seen to vary in about the same way. It should be remarked here that the threaded specimens required constant reclamping in order to preserve the original length, on account of the continued crushing of the tops of the threads. There was no slipping of the bolt in the clamp. Comparing the last two series of tests, 4 and 5, it is seen that the solid bolts required the greatest number of vibrations to rupture them; that they contracted less and elongated less. Figure 4 shows graphically the increase in the number of vibrations, to rupture, as the length increased. It should be observed that the outer fibers of the bolts at the lower edge of the clamps were overstrained when the tests were started, due to the great eccentricity under which the tests were made. Assumung a modulus of elasticity of 28,000,000, the fiber stress, due to flexure alone, is found to be in every case greater than 70,000 pounds per square inch. The actual fiber stress would be much less than this, since the formula does not hold true beyond the elastic limit.

Figures 5 and 6 show the relation between the elongation, measured by the machine, and the number of revolutions. These are only two typical curves selected from the total number taken. The lower line in each case represents the first few points, drawn to a magnified horizontal scale. All curves obtained showed a rapid elongation at first, up to a point which we may call A. Beyond this point, elongation took place much more slowly to a point B, when the piece elongated very fast to rupture. These points, A and B, are not so definitely marked in curves 5 and 6 as they are in the other cases where the tensile stresses are greater. This first elongation is greater in the hollow than in the solid bolts and greater for increased tensile stress for both, as will be seen by consulting Table I. It seems reasonable to believe that this first elongation, up to the point A, takes place while the bolt is being stressed beyond its yield point. After being overstrained throughout its cross section, it elongates less rapidly up to the point B, when the outer fibers have reached their maximum strength. The bolts then elongate rapidly until rupture occurs.

The results of the tests show : 1° That the fibers in the hollow iron seem to be more firmly united than in the case of the solid iron, as shown by the fractures; 2° that increasing the length of the threaded bolt increases the number of vibrations to rupture, even when the tensile stresses are increased; 3° that grooved solid staybolt iron requires a slightly greater number of vibrations to rupture it than the hollow, and that it contracts less and elongates less; 4° that the material shows a point of yielding a maximum point.

In closing, the writer wishes to acknowledge the efficient way in which I. W. Scott and C. A. Esslinger, senior students in mechanical engineering in Purdue University, assisted in carrying out the tests reported in this paper.

[621 .33]

ELECTRIC WORKING ON STANDARD-GAUGE LINES WITH STEEP GRADIENTS,

By Mr. MÜHLMANN, Esslingen.

Figs. 1 to 3, pp. 1234 to 1239.

(*Annalen für Gewerbe und Bauwesen.*)

On the main line of the Wurtemberg State Railway, which runs across the country from Mühlacker to Ulm viâ Stuttgart, the trains require most power where the line ascends the Swabian Alps. The steepest section, known as the "Geislinger Steig (Incline)" is between Geislingen and Amstetten; the distance between these two stations is 5·7 kilometres (3·5 miles), the difference of height is 113 metres (370 ft. 8 in.) and the gradient is 1 in 44·5. The conditions are already unfavourable before Geislingen; from Göppingen on, the rise is at first 1 in 150 and then (from Süssen on) 1 in 100. Moreover, just before Geislingen, there is a place where the line in going round a hill has a section 600 metres (0·37 mile) long with a mean radius of only 345 metres (17 1/4 chains).

A special push service for the trains is provided at the "Steig". Locomotives are stationed at Geislingen, which help to push the trains up the incline to Amstetten, and then return, running light to Geislingen.

In order to estimate the vast amount of energy obtained from steam, which is required on the "Geislinger Steig", I have taken an autumn day (1) and examined matters in detail. The amount of traffic was as follows :

Over the whole of the Geislingen-Amstetten section, 2,218 axles ran during the 24 hours, while the annual mean for the whole Wurtemberg system is 950. The rails of this section are, therefore, subjected to nearly two and a half times as much fatigue as the average Wurtemberg rail. Actually however, the fatigue is greater, as of the 2,218 axles nearly 25 per cent are axles of locomotives and tenders, whereas the average for the whole of Wurtemberg is only 17 per cent.

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(1) October 7, 1903. On that day, I worked as fireman on one of these push locomotives and took notes for the present paper, the completion of which was unfortunately delayed. The results however, still apply today and are even a little more in favour of steam traction as instead of the old six-wheeled locomotives (all wheels coupled) with separate tender, new eight-wheeled tank locomotives (all wheels coupled) are now used to some extent.

The weights of the ascending trains were as follows :

Inside the 24 hours, 35 trains went up; the wagons weighed 11,500 tons. 99 locomotives were used for the purpose, 51 for hauling and 48 for pushing, with a total weight of 6,600 tons. So that altogether 18,100 tons were taken up, *i. e.* raised 113 metres (370 ft. 8 in.). The work required for lifting only thus amounted to 2,046 million kilogram-metres (14,799 million foot-pounds). Adding the work expended in overcoming the friction and the resistance at curves, the total work amounted to 2,526 million kilogram-metres (18,271 million foot-pounds) or 9,359 horsepower-hours (9,231 British horsepower-hours). The total time taken by the 35 trains was 612 minutes, so that on the average, each train required 918 horse-power (905 British horse-power).

In this calculation, the formula taken for the resistance of curves was $\frac{650}{R - 60}$, for the friction of the wagons $1{\cdot}5 + 0{\cdot}001\ V^2$ and for that of the locomotives $4\sqrt{a} + 0{\cdot}002\ V^2$, where R = radius of curve in metres, V = velocity in kilometres per hour and a = the number of coupled axles of the locomotives. It was necessary to determine the friction figure for the locomotives and that for the wagons separately, as each train had more than the usual number of locomotives, and consequently, any formula for an average train $\left(\text{for instance } 2{\cdot}4 + \frac{V^2}{1{,}300}\right)$ would have given too low a figure. In any case, whatever formula may be selected is not a matter of much importance as far as the total resistance is concerned, as the chief factor is the height ascended.

I

The work of the pushing locomotives taken by itself is of greater interest. For the disadvantages involved in crossing a mountain range are summarized in this pushing service. In order to know what work it involves, it is necessary to know what proportion of the work done in going uphill is done by the hauling locomotive, and what proportion by the rear locomotive. In making this division, I assume that each locomotive works in proportion to its power. Whether this actually is so, is not certain; but it is very probable.

On this assumption, 4,541 horsepower-hours (4,479 British horsepower-hours) are contributed by the rear locomotives and 4,818 (4,752 British horsepower-hours) by the front locomotives. As the rear locomotives are mostly twin-cylinder locomotives of older construction, these 4,541 horsepower-hours (4,479 British horsepower-hours) require about 10 tons of coal, running light and station work included. Now as these 10 tons apply to a busy day, the amount required per year will be about 3,000 tons of coal, costing about 60,000 marks (£3,000).

Now as regards descents :

On the day in question, within the 24 hours 35 trains ran down, and in addition 23 locomotives running light. The weight of the wagons was 11,500 tons, the weight of the wagons plus locomotives and tenders about 18,400 tons. In making these descents, 1,582 million kilogram-metres (11,443 million foot-pounds), *i. e.* 5,865 horse-power-hours (5,785 British horsepower-hours) of work, had to be absorbed by the brakes.

If we leave out of consideration the rear locomotives, which ran down unattached to trains, the weight of the 35 trains was 15,165 tons (14,925 English tons); when these descended, 1,340 million kilogram-metres (9,692 million foot-pounds), *i. e.* 4,963 horsepower-hours (4,895 British horsepower-hours) of work, had to be absorbed by the brakes; so the average brake-work is about 480 horsepower-hours (473 British horsepower-hours) for each train.

The work performed by the rear locomotives and the work which had to be absorbed by the brakes, are shown in figure 1 as a function of the time. The period of starting is not specially taken into consideration, and moreover, it is assumed that the rate of work remains constant during the whole journey. This seems admissible, as the work due to difference of height far outweighs any other, and as the gradient on the whole section is uniform. Only at each of the two terminal stations is there a short horizontal section; the work entered on figure 1 for these sections is therefore not utilized in gaining height, but is available for producing acceleration. Anyhow, not much work is required for producing acceleration; thus the quickest train, train no. 1 which makes the ascent in 10·5 minutes, *i. e.* with a velocity of 9 metres (29 ft. 6 in.) per second, and weighs together with its three locomotives 487 tons (479 English tons), only requires for its acceleration about 2 million kilogram-metres (14,466,000 foot-pounds). But the same train requires for the whole section from Geislingen to Amstetten 72·5 million kilogram-metres (524,403,000 foot-pounds); the acceleration thus accounts for less than 3 per cent. This figure is still lower in the case of goods trains, amounting to hardly 1 per cent.

Diagram 1 and the annual expenditure of 60,000 marks (£3,000) on coal, induce us to consider whether it would not be possible to utilize the energy, at present wasted, of the descending trains for the ascending rear locomotives.

This would only be possible by some electrical method. It would be necessary to use electric locomotives at the rear of the trains, and the whole section would have to be equipped with an overhead conductor. The electric locomotive would no longer run down alone, but would be placed in front of the descending trains (the front locomotive of course remaining); its motors would act as dynamos and the trains would be braked, their energy being transformed into current.

Now as figure 1 shows, the trains are not arranged so that simultaneously one train runs uphill and another downhill, in which case the energy generated by the descending train could be utilized direct by the ascending rear locomotive. It is out of the question to arrange the time-table so as to have such a train service. The electric service would have to be organized so that it could also be used as a shuttle service. For this purpose, a power station and a powerful accumulator battery are required.

The electric locomotives would, on account of the battery, require to have continuous current motors, and as they are to return current, they must have shunt wound motors.

Two difficulties in operating on this system at once appear : firstly, the disadvantage that the descending trains must stop in Amstetten, to enable the electric locomotive to be placed in front, and in Geislingen, to take it away again; at present the express trains run through both stations (or at least through Amstetten) without stopping.

Secondly there are the unequal speeds of the different trains; at present express trains and goods trains run at different speeds, both downhill and uphill. If an electric service were organized, it would thus be necessary either to have two kinds of locomotives for the two different speeds, or to have one kind of locomotive only and obtain two speeds from this by changing the way in which the motors are coupled up, or thirdly, to alter the time-table so that all trains would run at the same speed, both uphill and downhill.

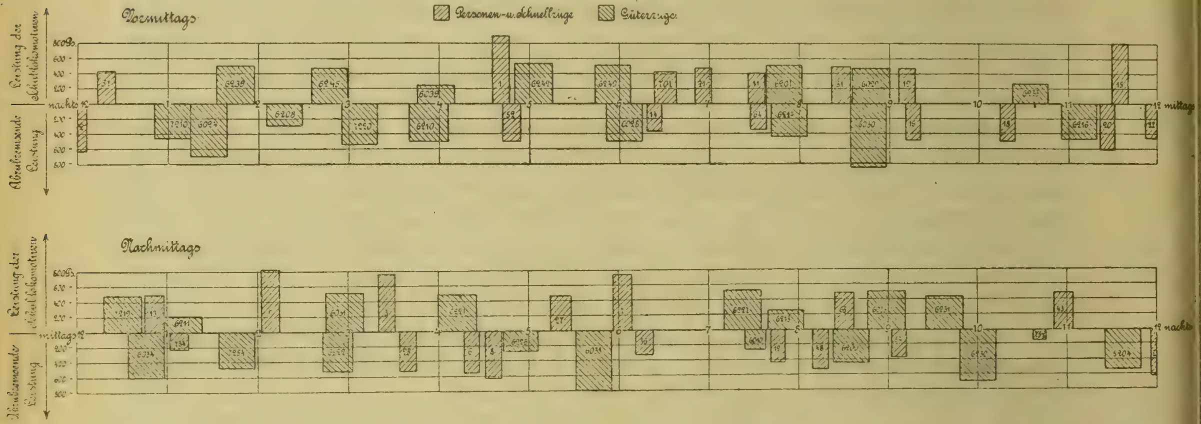


Fig. 1. — Work of push-locomotive and work to be absorbed by brakes on the Geislingen-Amstetten section (acceleration when starting not included).

Explanation of the German terms : Abzubremsende Leistung = Power to be absorbed by brakes. — Güterzüge = Goods trains. — Leistung der Schublokomotiven = Power developped by push-locomotives. — 12 mittags = Noon. — Nachmittags = Afternoon. — Nachts 12 = Midnight. — Personen- u. Schnellzüge = Passenger and express trains. — Vormittags = Morning.

Neither of these three solutions is free from objection. The first has the disadvantage that a greater number of locomotives is required, as goods and passenger locomotives would not be interchangeable. The second has the disadvantage of the low efficiency of the material used for the motors in the cases in which they work at half the normal voltage, that is at reduced speed. The third has the disadvantage that the locomotives used at the tail of a goods train when ascending the incline would be much more powerful than the steam locomotives used for the pushing today, and would consequently have to be larger and more powerful.

Diagram 1, which applies to the steam service, would have to become modified if electric locomotives wese used; the following alterations would be required :

1° The velocities of the train would have to be adjusted to suit the type of electric locomotive selected;

2° The work required to take a steam locomotive up the incline would have to be replaced by the work required to take an electric locomotive up;

3° In running downhill it is not possible to transmit the whole of the energy liberated in the train to the electric locomotive, but only such part as the latter can deal with; the rest of the energy must be taken up by the air brakes or the hand brakes, as at present.

Let us for instance assume that the type of electric push-locomotive selected has a total weight of 52 tons (51·18 English tons), all wheels being driving wheels, and can thus give at the tread of the wheels a force of 8,000 kilograms (17,640 lb.) when running uphill and take up the same when running downhill. On a downhill gradient of 1 in 44·5, this locomotive requires 1,000 kilograms (2,205 lb.) (at the tread of the wheels) to brake its own weight; the maximum it can therefore take from a descending train is 7,000 kilograms (15,430 lb.). But most of the goods trains want much more than 7,000 kilograms (15,430 lb.) for proper braking; thus goods train No. 6030 requires even 15,400 kilograms (33,950 lb.). Consequently, most goods trains would require two such electric locomotives, some even three if all the energy of descending trains is to be utilized.

Whether two or even three electric locomotives are to be placed in front of the descending trains, depends to a large extent on the organization of the working of the traffic;

4° The positive ordinates must be divided by 0·85, and the negative ones multiplied by 0·75 in order to allow for the losses in the motors and the overhead conductors. Then these smaller negative ordinates have to be subtracted from the larger positive ordinates. The diagram so obtained gives the amount of current in the overhead conductors.

We have not proceeded to redraw the diagram in this way, as the following rough calculation shows the hopelessness of the whole project of an electric push-service. The ascending push-locomotives require 4,541 horsepower-hours (4,479 British horsepower-hours), measured at the tread of the driving wheels, *i. e.* $\frac{4{,}541}{0{\cdot}85} = 5{,}340$ horse power-hours (5,267 British horsepower-hours) in the overhead conductor; the descending trains at most give 4,963 horsepower-hours (4,895 British horsepower-hours), measured at the tread of the driving wheels, *i. e.* $4{,}963 \times 0{\cdot}75 = 3{,}720$ horsepower-hours (3,669 British horsepower-hours) in the overhead conductors. Further losses of current will result, more especially for the reasons mentioned under 3° and in connection with the accumulator batteries. The dynamos at the central station must therefore generate at least 2,000 horsepower-hours per day; this involves a coal consumption of $2{,}000 \times 300 \times 0{\cdot}0015 = 900$ tons per year, costing 18,000 marks (£900).

If the present traffic regulations are kept in force, according to which only one train may be going uphill on the Geislingen-Amstetten section and only one going downhill at one and the same time, the accumulator battery must be sufficiently large to be able to take up the strongest currents a descending train can produce, *i. e.* about 500 kilowatts. The capital cost of the central stations, the accumulators and the conductors (about 12 kilometres [7·5 miles] long) may be estimated at about a million marks (£50,000); the interest and amortization required would be about 50,000 marks (£2,500) per year.

Hydraulic accumulation instead of batteries would not be more favourable, as no river is in the neighbourhood and very large dams would be required up above and down below. Much more capital would be expended, as a pumping station equivalent to 500 kilowatts would be required, *i. e.* about 250 litres (55 British gallons) per second.

To use a fly-wheel, instead of a battery, for dealing with the variation in the load is impracticable, as the amount of energy concerned is too great and the time between taking up and giving out energy too long.

The electric push-service can accordingly not compete with steam, as with electricity the items of coal, interest and amortization alone already amount to 68,000 marks (£3,400) per year, as against 60,000 marks (£3,000) for the coal required by the steam locomotives used at present. In the figure given, the maintenance and renewals of the central station and of the conductors, the wages for the employees at the central station, and above all the expensive maintenance of the accumulator batteries, are not included.

II

The project of recovering the energy of the trains running downhill is therefore only worth consideration, if it is possible for the central station to have a correspondingly larger and more uniform load.

The idea then arises to extend the electric system further, perhaps to Göppingen, so as to utilize the energy of all the descending trains on the trains ascending from Göppingen. In other words : assume all the lines of the State Railway operated electrically, so that all steam locomotives are replaced by electric locomotives; let us then assume that the section Göppingen-Amstetten is a separate section independent of the adjoining sections.

The performance of all the locomotives and trains which ran on the day in question on the Göppingen-Amstetten section, were worked out and plotted as a function of the time in diagram 2, the work done by the locomotives as positive ordinates, and that absorbed by the brakes as negative ordinates (both measured at the tread of the wheels). In this calculation, the whole section was divided into four parts, and it was assumed that in each of these four parts the performance remained constant. These four parts are :

	Mean gradient.
Göppingen-Eislingen, 4·03 kilometres (2·50 miles)	1 in 200.
Eislingen-Süssen, 4·30 kilometres (2·67 miles)	1 in 150.
Süssen-Geislingen, 10·88 kilometres (6·76 miles)	1 in 100.
Geislingen-Amstetten, 5·72 kilometres (3·55 miles)	1 in 44·5.

As the gradients in each of these sections vary but little from their mean gradient, the assumption of a constant performance may be quite justifiable.

It must be noted that in this case also the energy used in accelerating the trains has not been taken into consideration.

The resulting diagram 2 shows that the ascending trains together required 22,721 horsepower-hours (22,410 British horsepower-hours) and that the brakes of the descending trains had to take up 10,527 horsepower-hours (10,383 British horsepower-hours), both measured at the tread of the wheels. The ratio of these two figures, the proportion of energy recovered, thus amounts to 0·465, measured at the tread of the wheels, and measured in the overhead conductors to

$$\frac{10{,}527 \times 0{\cdot}75 \times 0{\cdot}85}{22{,}721} = 0{\cdot}3.$$

As however in diagram 2, the present distribution of the energy of the steam locomotive is plotted, it should strictly speaking be modified in the case of electric working in accordance with the above mentioned four points.

It is to be noted, as regards point 1°, the alteration in the velocity of the trains, this but little affects the total energy required, but only increases or reduces the output required at a given moment.

As regards 2°, the smaller weight of the electric locomotives will reduce both the positive and the negative ordinates of diagram 2, although not in the same proportion. Consequently the saving of energy effected by electric working as compared with steam working is very small; the following calculation shows it is about 3 per cent.

Let us for instance assume that we have electric locomotives of the following two constructions :

For goods trains, a locomotive with eight wheels, all coupled, weight 52 tons (51·18 English tons), normal 600 horsepower; for express trains a locomotive with ten wheels, six coupled, total weight 70 tons (68·9 English tons), adhesive weight 42 tons (41·34 English tons), normal 900 horsepower.

The former electric locomotive would replace the present six coupled-wheel steam locomotive used with goods trains; this weighs together with tender 67 tons (65·94 English tons), the adhesive weight being 45 tons (44·29 English tons.)

The latter electric locomotive would replace the present steam locomotives used with express trains and passenger trains; these steam locomotives have 8 and 10 wheels, 4 and 6 coupled, weights with tender 80 tons and 100 tons (78·7 and 98·4 English tons), and adhesive weights 30 and 45 tons (29·5 and 44·3 English tons) respectively.

On the day in question five trains, total weight of cars 1,069 tons (1,050 English tons), were taken uphill by the ten-wheeled express locomotives. The five steam locomotives weigh, tenders included, 500 tons (492 English tons), the 5 electric locomotives only 350 tons (344 English tons). The work saved is therefore $\frac{500 - 350}{500 + 1{,}069}$ = 9·6 per cent.

Of the descending trains, six had the same ten-wheeled express locomotives; the weight of the cars was 1,192 tons (1,173 English tons). The reduction in brake-action is thus $\frac{600 - 420}{600 + 1{,}192}$ = 10 per cent.

Similarly in the case of the passenger train locomotives with eight wheels, four coupled, the work saved is 7 per cent and the reduction in brake-action is 7·4 per cent; finally in the case of the goods trains, the work saved is 6·6 per cent and the reduction in brake-action is 6·4 per cent.

The mean figures for all the trains are 7·28 and 7·35 per cent respectively. Taking

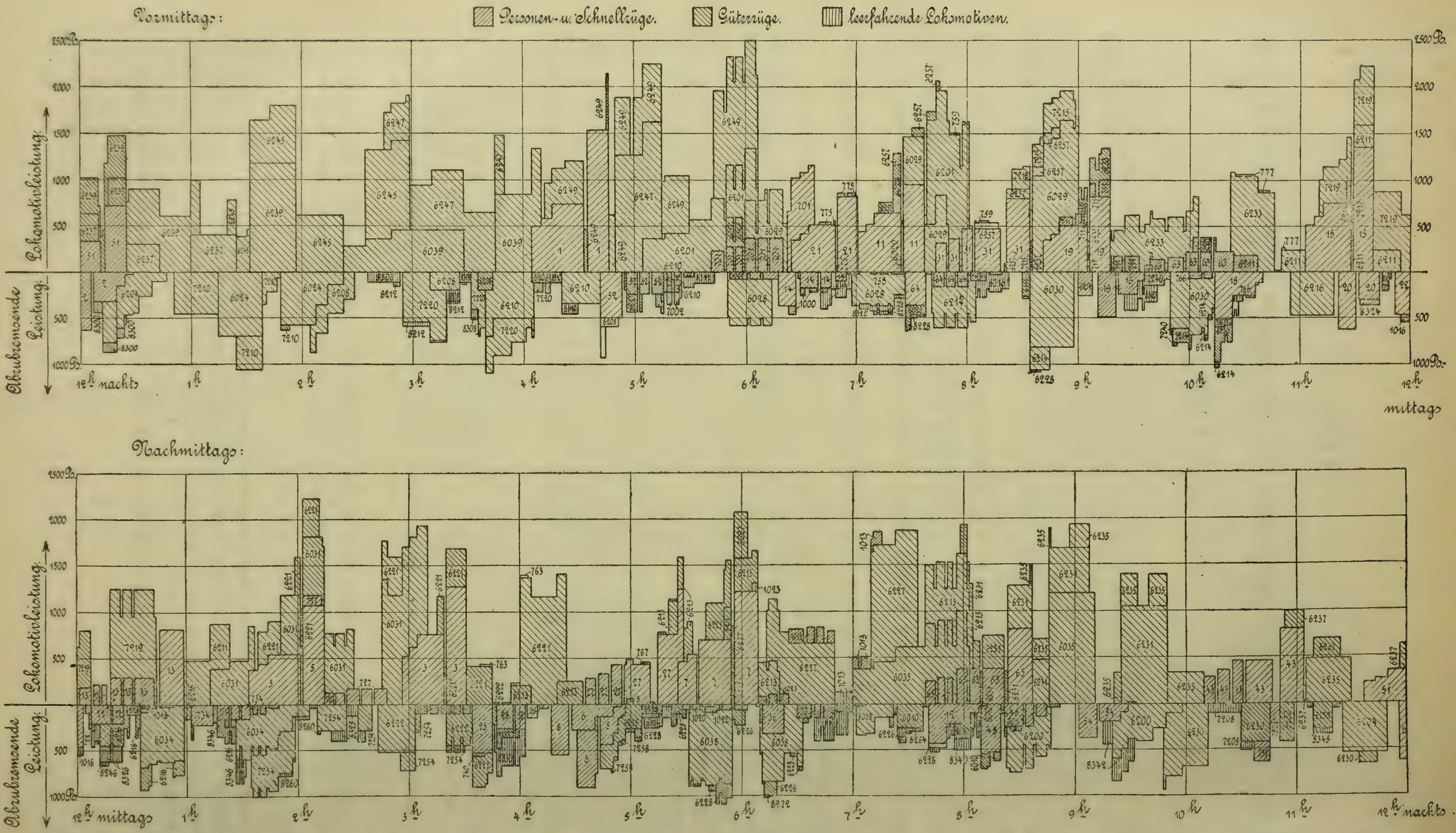


Fig. 2. — Power developed by ascending locomotives and power developed by descending trains, to be absorbed by brakes, on the Göppingen-Amstetten section (acceleration when starting not included).

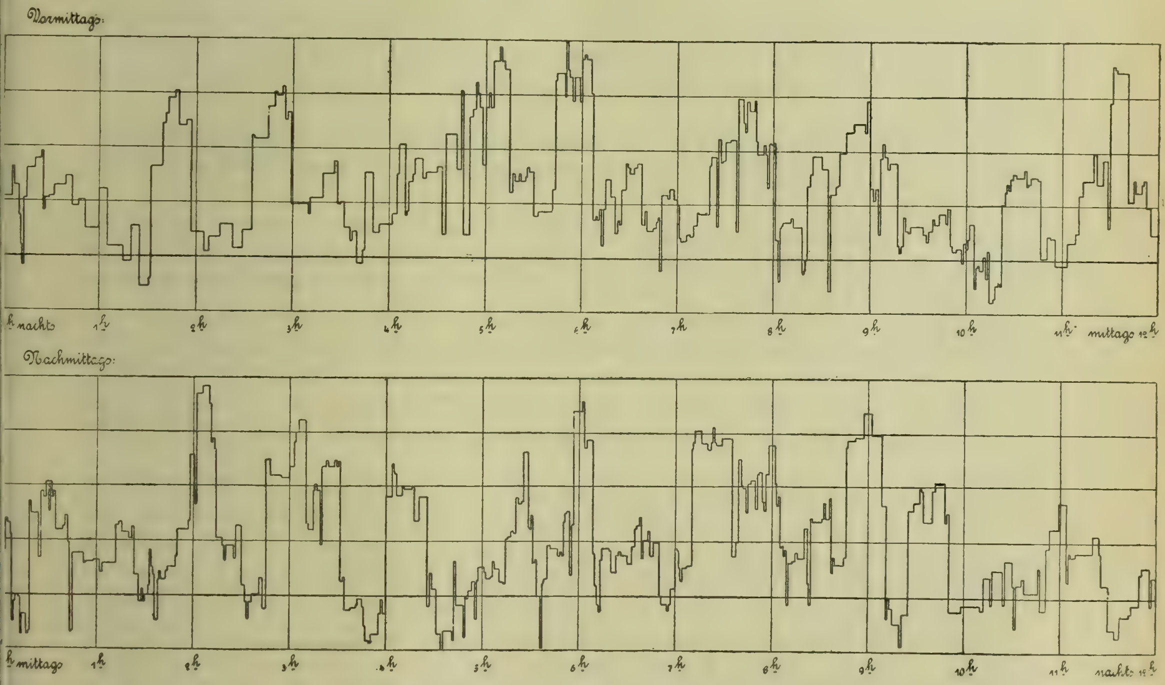
Explanation of the German terms : Leerfahrende Lokomotiven = Locomotives running light. — Lokomotivleistung = Power developed by locomotives.

into consideration the coefficients 0·85 and 0·75, considered above, the saving of energy effected by electric working is

$$\frac{7{\cdot}28}{0{\cdot}85} - 7{\cdot}35 \times 0{\cdot}75 = 3 \text{ per cent.}$$

Point 3° does not necessitate any alteration in diagram 2, as all the locomotives are worked electrically, and thus when going downhill exercise a brake action, so that all the energy of the descending trains can be recovered; of course on the assumption that the special electric locomotives are used on the Geislinger Steig proper, these locomotives acting as push-locomotives uphill and as brake-locomotives downhill.

Point 4° is taken into consideration in figure 3, which shows the load in the overhead conductor and is obtained from figure 2 by multiplying the negative ordinates by 0·75 and dividing the positive ordinates by 0·85 and subtracting the former from the latter.



ig. 3. — Load of overhead conductor on the Göppingen-Amstetten section (acceleration when starting not included).

It is accordingly reasonable to retain diagrams 2 and 3 for showing the distribution of the quantity of power required during the different hours of the day, whereas its magnitude and its daily total are altered a little if electric locomotives are taken instead of steam locomotives.

With steam working, 22,721 horse-power-hours (22,410 British horse-power-hours) (measured at the tread of the driving wheels) are required for the ascents, whereas with electric working (14,400 — 540) 0·97 = 13,500 kilowatt-hours (measured in the overhead conductors) are required.

How these quantities of current are to be generated, we do not propose to consider here. Continuous current may be generated at the central station or rotatory current, which is then transformed at substations into the working current; but in each case, the irregular character of load curve shown in diagram 3, with its many apices will make it necessary to have arrangements for storing energy, all the more so, as in all three diagrams, the energy used in acceleration at the start is not taken into consideration, and this would make the apices rise still further and make the curve in diagram 3 still more irregular.

Now as regards the comparative cost of steam and electric working, it may be assumed that the maintenance of the track, the maintenance and cost of the locomotives and cars, the signal and station service, and all other general expenses of this kind, will cost the same in both cases. Similarly no economy will result in the driving.It is true that two men are not required for driving merely, as the handling of an electric locomotive is simpler, but consideration for the safety of the train service makes this necessary on such an important and busy section as the one in question.

Therefore the main factors in the comparison are the cost of coal burnt on the steam locomotives, and the cost of the current taken from the overhead conductors in electric working.

According to diagram 2, the steam locomotives will at most use 50 tons of coal per day, costing about 1,000 marks (£50). If therefore electric working is not to cost more than steam working, it must be possible to supply the 13,500 kilowatt-hours required in the overhead conductors at a cost of not more than 1,000 marks (£50), *i. e.* at about 7·5 pfennigs (0·9*d.*) per kilowatt-hour. In these 7·5 pfennigs (0·9*d.*) must be included : interest and sinking fund of capital cost of power station and overhead conductors, cost of maintenance of this whole installation, pay of employees at power station, and cost of materials, especially of the coal burnt at the power station.

To keep the cost of current so low with such an irregular load, will either not be possible at all, or only if the power station can profitably utilize its current for other purposes in addition; for purposes which require a supply of energy, both day and night, as constant as possible. Consequently the lighting of large stations or of towns is not calculated to make such an electrical undertaking profitable, as current is only wanted in the evening and then in large quantities; it would be more advantageous to supply current to electromotors used for industrial and agricultural work; the best would probably be electro-chemical works.

Thus without considering the details of the electrification this example shows that electric working cannot straightway compete financially with steam working, although the section here considered is favourable to electric working, as energy is recovered in running downhill.

[656 .253]

OVERRUNNING SIGNALS (1),

By Mr. SCHOLKMANN.

(*Zeitung des Vereins.*)

As we know, the German signalling regulations are based on the assumption that the driver can always clearly see the distant and home signals. This assumption is quite true. When however the weather is not clear, the time during which the driver can see the signal is very short, often only a fraction of a second.

As lately several serious accidents have taken place because stop signals were overrun, the administration of the Prussian State Railway decided to make tests, on a large scale, of the different devices intended to draw the special attention of the driver during thick weather to any stop signal. In the course of these tests, all the devices brought out up till now were considered, and a description of them will show that it is probably impossible to recommend the general application of any given device, and that local and service conditions make varying devices necessary, and that these in any case only have the character of makeshifts.

The proposals made to draw the attention of the driver during thick weather to stop signals, may be divided into the following groups :

I. — *Use of light for the purpose : a*) Making the signal light brighter; *b*) Having additional signal lights; *c*) Putting up visible landmarks.

II. — *Audible signals : a*) Detonators; *b*) Bells, sirens, whistles, horns; *c*) Audible landmarks.

III. — *Audible and visible signals.* Detonators also producing a bright light.

IV. — *Signals repeated on locomotive : a*) Transmission by mechanical means or by electric energy; *b*) Magnetic transmission, induction, condensers, etc.; *c*) Transmission by electric waves.

V. — Devices which show on the locomotive where the signals are located, but not whether they are on or off.

Each group includes many proposals and inventions.

I*a*. — Increasing the illuminating power of the signal lamps would hardly give satisfactory results, as it appears impracticable to have a source of light sufficiently strong for the most unfavourable conditions, at least in the case of distant and main signals. Electric signal lights do not penetrate a thick fog better than good petroleum lights, and experiments with acetylene have nowhere given satisfactory results.

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(1) See *Zeitung des Vereins*, 1907, No. 27; 1906, No. 65 and 1904, No. 69.

Whether the new distant signals, extensive trials of which are being made, will be more satisfactory remains to be seen. They have the advantage, as compared with the present distant signal, that they show two red-yellow lights when at danger and two green lights when at safety.

I*b.* — Messrs. Siemens & Halske have proposed (German patent No. 112622) to put in additional signal lights at suitable points, and have these lights so near the driver's eyes that he must see them. This *fog light signal* consists of several lights located between the distant signal and the main signal close to the track at such a height as to be level with the driver's eyes; these may be said to act as an extension, to the driver's eye, of the usual light. This system, which taken by itself would be suitable, has the disadvantage that it can only be applied where high-pressure current is available, as otherwise the arrangements required for the lights and glasses would be very complicated and difficult to keep in order.

I*c.* — It has been proposed to put up landmarks in order to show where the signals are. These can be of use in assisting the driver's sense of locality, and their adoption can therefore be recommended, particularly as they are easily put up. But they do not satisfy requirements when there is fog, unless they are well illuminated. In most cases however, the lighting of the lamps is a matter of considerable difficulty, and lamps giving a very strong light are required.

II*a.* — Detonators have already been extensively used, as extra signals in case of fog, for many years in many places, but they after all remain a makeshift. The noise made by fast trains deadens the sound of the detonation; and placing the detonators on the track is a very troublesome matter (*see* III below).

II*b.* — Until lately, bells, sirens and whistles, generally set in action by the train, have been tried in many places. All the trials made have however confirmed the observation already made twenty years ago on the Prussian railways, that in the case of a fast train, the time for hearing the sound is too short and the noise of the train interferes with the sound.

Quite recently, electrically operated horns have been put in as an experiment on the Prussian State Railway to give the driver of a train stopped at a distance from the signal cabin a signal acknowledging receipt of his call signal. The trials have given such favourable results that horns are now to be added to a large number of signals in order to inform the driver if the signal is at danger. These horns are similar to motor car horns. Each signal is to be supplemented by two or three horns placed, at intervals of 50 or 100 metres (55 or 110 yards), near the distant signal, and they are to be fixed on posts about 3 metres (10 feet) high placed 2·5 metres (8 ft. 2 in.) to one side of the axis of the track. The openings of the horns are adjusted to face the direction in which the train goes. These horns are operated by a low-pressure current. The battery is located in the signal cabin and the current is switched on by the signalman. There are contacts which complete the circuit as soon as touched by the locomotive wheel, if the signal it at danger; thus the horns are sounded automatically.

This signal has advantages; but it also has the disadvantage that if the apparatus fails, the same condition of affairs results as if the signal was at safety. That is so, although very convenient provision is made to test all the parts as to their durability. Moreover, it will hardly be possible to use these horns where there are houses, as the noise they make is objectionable.

IIc. — It has also been proposed to place echoing walls near the tracks, which are to act as audible landmarks marking the location of the signal. Their value for this purpose appears very doubtful, as their efficiency can be much reduced by bad weather (thunderstorms, winds); then also other articles near the track (fences, boards) might have a similar action.

III. — Better results than with the ordinary detonators, set off by the wheels, may be expected from signals that are both audible and visible; such are the detonators, producing a strong light, manufactured by Seuthe in Hetschburg (Weimar). The trials made with this, which have already been carried out for some time, show that in addition to a strong detonation, a strong light is produced, of over 2,000,000 candle power, which the driver is bound to notice, even when there is fog. Experiments have also shown that the cartridges can remain in water a considerable time without becoming useless; the administration of the Prussian State Railway has therefore decided to make a trial, on a large scale, with these detonators.

Naturally the same difficulties arise in the putting in place of these detonators as with the ordinary detonators. Even technicians sometimes advise that in order to avoid the running through of stop signals, all that has to be done is to place detonators, if required, at the signals, and refer to English railways as instances. But in doing so, they leave out of consideration the peculiarities of German signalling arrangements, and the difficulty of always finding at the right time the number of men required for placing the detonators on the rails. These difficulties have not yet been overcome in the country where fogs are thickest and most frequent, and where detonators have already been used for many years. This is no doubt the reason why of late numerous experiments are again being tried in England with devices which are intended to show on the locomotive what the position of the semaphores is.

Many trials have already been made with appliances for placing the detonators on the track (fog machines). These contain a considerable number of detonators, so that they have to be recharged at long intervals only; and they are operated by the signal transmission. None of these appliances have however proved satisfactory. They are all very complicated and unreliable. Besides this, it is quite out of the question, on the Prussian State Railway, to operate any such fog machines by the transmissions, for there it is usual to work both the distant signal and the main signal by one lever, and consequently the transmission is often already so heavily loaded by alterations of direction, etc., that any addition to the load would endanger the proper working of the signals.

The only feasible system left, on the Prussian State Railway, is therefore to have special men to operate the fog machines for the entrance signals. But when fog suddenly occurs, such men are only definitely available at larger stations and at the places (numerous, it is true) where the distant signal is near a level crossing. For there is probably no doubt that the detonators should not be very far from the distant signal, although sundry disadvantages result, as they then very frequently are set off and compel the driver to stop the train by all available means.

The conditions are much more favourable for detonators in the case of the block signals. In this case, the detonators can be placed close to the block signal, as the train will nearly always find the distance required for stopping clear. There is the advantage that the detonators are very seldom run over, and therefore do not have to be replaced often. Moreover, the fog machine can be directly connected with the wire transmission, as in the case of block signals, there is as a rule only one change of direction and no locked pulleys, so that the addition of the fog machine does not overload the wire.

Detonators have naturally certain defects which cannot be remedied : the signal man cannot be compelled to recharge the fog machines or to operate the fog machines, and the detonations are very objectionable to those living near.

IV*a*. — A very large number of proposals and trials have been made having as object to show the position of the signal arms on the locomotive or to put the brakes on automatically if a stop signal is reached. For it seems so extremely simple to make a train stop at a stop signal : place near the signal a rod or other object which projects so as to strike against a lever on the locomotive, which puts on the brakes, or sounds the whistle, or gives some other indication; or else produce the same effect by a circuit on the locomotive, completed when the locomotive passes over a treadle. But nearly all the devices proposed are of no use. Firstly it is very difficult to make the transmission gear, from track to locomotive, sufficiently durable when high speeds are in question; secondly, most of the devices have the disadvantage that they only show when the signal is at danger and not when it is at safety. But if no signal appears because the apparatus is out of order, this is a direct source of danger, as if the apparatus has acted perfectly for some time, the driver may become careless and rely on it. Therefore all devices by means of which the position of the semaphore arms is to be shown on the locomotive, must satisfy the further condition that the driver is to receive some indication if they do not act. The result is that such devices consequently have to be so complicated that their maintenance is exceedingly difficult.

In some cases, satisfactory results have certainly sometimes been obtained when such devices have been tried, particularly if a specially trained staff was available; but it is none the less true that after careful and expensive trial, these devices have been discarded except at places under the control of their inventor.

The administration of the Prussian State Railway decided, for these reasons, not to make any extensive trials of devices which were intended to show the position of the semaphore arms on the locomotive, and only to try at three different places the Van Braam apparatus, which acts on the brakes, so as to produce an ordinary stop at the distant signal and an emergency stop at the main signal if the signal in question is in the "danger" position. It would take too long to give a description of these apparatus, which are at present being put in, so that no opinion can as yet be formed as to their capabilities.

IV*b*. — The appliances in which mechanical transmission is replaced by electric or magnetic transmission have been even less satisfactory. To this class belong iron rods placed along the rails and surrounded by coils, which are magnetized by electric current when the signal is in the " danger " position and which act on galvanoscopes carried on the locomotives, and other devices whose action depends on induction and condensation phenomena. All these devices are only of use for laboratory experiments. The actual distances between the moving and the stationary masses are such that the action can be but a minute one, and will only affect exceedingly delicate and complicated instruments, and such would have no durability in locomotive work, nor would it be possible to protect them against casual influences. Such devices need not be considered; indeed owing to the absence of any prospect of success, they have not been introduced anywhere.

IV*c*. — If electric waves were used, there would probably be fewer difficulties in the way of transmitting the signals to the moving trains, if reliable receiving instruments could be placed on the locomotive. These receiving instruments must only be affected by their own proper waves and not perhaps also by the waves intended for a train on the other track. Syntonized instruments cannot be used for the purpose, as the locomotives cannot always be running on the same track and it would be impracticable to change or alter the instruments under ordinary traffic conditions. In this case also, the condition must be laid down, as in the case of all other instruments liable to break-down, that if the apparatus fails the danger signal must appear. To what extent wireless telegraphy will satisfy this requirement, and the other strict conditions which the safety of railways involves, remains to be seen, as the information obtained up to the present in other ways gives us no basis for comparison. It is here not a question of transmitting a message, no matter whether more or less accurate, to a train; nor can large instruments requiring much room and good accommodation in the train, looked after by specialists, be in question. On the contrary, what is required is an instrument occupying but little roem, fixed in the cab, readily accessible and easy to observe, which works with accuracy and gives clear unmistakable signals with proper certainty.

V. — The devices proposed for showing on the locomotive the position of the semaphore arms, can evidently be much simplified if the only object is to inform the driver of the locomotive that he is approaching a signal. In such a case, some signal should appear in the cab about 150 to 200 metres (165 or 220 yards) before the distant signal, to draw the driver's attention to the fact that he is approaching a signal and must look out whether this is at " danger " or " safety ".

Conditions are much easier in this case than in the last. The interdependence between the track appliance and the semaphore, difficult to obtain, is eliminated and the instruments in the cab can be materially simpler, and consequently more durable, than instruments which are to show the position of the semaphore arms; moreover, it is easy to satisfy the fundamental condition that the driver is informed if the apparatus breaks and no longer acts.

The " signal announcer " (*Signalmelder*) which the Prussian State Railway proposes to try on a larger scales consist, firstly of a metal rail 10 to 15 metres (33 to 49 feet) long, which projects into the boundary of the locomotive templet either from the side or from below, and is connected to earth; it is placed 100 to 150 metres (110 to 165 yards) in advance of the distant signal. Secondly, there is an announcer on the locomotive. The latter includes a battery which continuously sends a current from its positive pole through brushes, insulated from the rest of the locomotive, to an electromagnet of the announcer and thence through earth to the negative pole. The armature of the electro-magnet is kept attracted by the continuously flowing current, and this keeps from sight a disk with an appropriate inscription such as " attention ", " signal ", etc. A second circuit, with an alarm, is normally open. When the locomotive and the brushes pass over the rail, the electro-magnet is short-circuited and the armature drops. This brings the disk behind a glazed opening in the front of the announcer, and closes the alarm circuit at the same time. If anything is wrong with the circuit, the armature drops and gives the alarm signal; the same happens if a brush breaks.

Experiments extended over a period of time are necessary before it can be ascertained whether this theoretically correct solution will work in practice; more especially whether it will be possible to keep the battery going a sufficient time and whether the shaking will not affect the instrument in the cab. A similar device is being tried on the Great Western Railway, which however goes further and also shows the " line clear " signal on the locomotive; so far results seem satisfactory.

Preparations are also at present being made on the Berlin-Stettin line for a series of trials; in these the driver is to be informed, by means of a similar arrangement to that just described, but operated by means of electric waves, that he is approaching a signal. In this case also the principle of continuous action is applied, so that in case of failure the danger signal appears on the locomotive.

There will scarcely be a technician who will not be of opinion that when considering all these devices the main points must not be forgotten, namely to have the signals clearly visible and recognizable, and above all to have properly trained drivers well acquainted with the road. Whatever additional devices may be adopted, they must not tend to make the drivers less careful; on the contrary, it remains as necessary as ever to do everything possible to induce the drivers under all circumstances to look out carefully and continuously for the signals while the train is running. Similarly, care must be taken to have proper brakesmen, well acquainted with the road. The latter are often responsible for the overrunning of signals, as unfortunately no means have yet been devised for making brakesmen keep on the alert and for increasing the sound of the steam whistle to a sufficient extent to make it sure that it will be heard at the tail of a long goods train when it is bad weather.

In order to make the train crews efficient from the point of view of keeping attention, it is evidently advisable to investigate all cases of overrunning signals, in which no accident has occurred and which consequently at present remain unknown. With this object in view, extensive trials are to be made with a simple counting mechanism, connected with the signal lever and a rail contact near the signal, and placed in the station building; this is arranged so as to record automatically every time the signal is overrun.

[625 .175]

RAILWAY CYCLE (1),

By A. HONEMANN,

GOVERNMENT ARCHITECT, DANZIG-LANGFUHR.

Figs. 1 to 10, pp. 1249 and 1250.

(*Organ für die Fortschritte des Eisenbahnwesens.*)

In order to enable a bicycle of ordinary make to run on the rails of a railway, it is absolutely necessary to have a lateral support or guide, to prevent the falling over of the cycle, which has to keep to its narrow track, namely to the rail head. The device must moreover not be affected by alterations in the gauge, otherwise the tires would be liable to slip off the rails. The greatest difficulty, however, arises from the switches and from the gaps at the frogs. If this difficulty is overcome, there is the further requisite that the device must be light and easy to attach and detach. The number of patents taken out for such devices show the importance of the question (2).

Of late Mr. O. Grasshoff, engineer, of Dantzig, has been offering a device, patented in Germany, which seems to satisfy the different requirements. The author has made a number of trial runs with an experimental machine, which show that the ideas on which the patent is based are correct and which gave excellent results.

These trial runs had as result that some modifications were made in the pattern originally patented; these do not affect the principle of the machine, but result in material simplification.

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(1) German patent 182539.

(2) United States — 615237, 1898.
— — 551834, 1895.
— — 542254, 1895.
— — 608071, 1898.
— — 499581, 1893.
— — 606073, 1898.
— — 545474, 1895.
— — 464357, 1891.
German — 111560, 1900, class 20 c.
British — 24735, 1896.

Figure 1 shows the arrangement. The front wheel *a* is loosely guided by the guide wheel *b* supported in the fork *f*; the fork and guide wheel can be lifted out of the way into the position shown by the dotted lines. The guide wheel *b* has an inner flange *h* and an outer flange *i*; this is conical so as to make it easier for wheel *b* to mount wing rails and to prevent it from sticking between a switch blade and a stock rail, when the two latter are in contact. The two flanges can be displaced relatively to each other. The movement of fork *f* while the cycle is in use is limited by the two forked arms *c* and *d* and the stop *e*. As soon as the wheel *b* passes on to a gap and is no longer supported, the arm *c* takes against the stop *e* which is movable relatively to the fork *g* and thus the wheel *b* is prevented from dropping. The play between the arm *d* and the stop *e* is so adjusted that the flange *i* of the wheel *b* can mount the rail; if, however, wheel *a* is over a gap and no longer supported, it is depressed by about the depth of flange *i*. Then the arm *d* takes against stop *e* and prevents the further dropping of wheel *a* (fig. 2).

The back wheel *l* (fig. 1) is prevented from leaving the rail by the two wheels *p* and p_1; *p* has no flange and p_1 has the same shape as *b*. On account of the large load a connection is provided instead of the arm *d*. This connection consists of two tie-rods *m*, one on each side of the wheel, which hold wheels *p* and p_1 together; a spring *r* is inserted in each tie-rod. The spring *r* is placed between disk *n* which can slide on rod *m*, and disk *o*, which is firmly connected with the box containing the spring; it has sufficient play to enable the wheel p_1 with its flange i_1 to mount the rail. If the wheel *l* is over a gap, the spring *r* is compressed until disk *n* takes against disk *o*. Then the rods *m* and the forks f_2 and f_3 form together a rigid triangle, which prevents any further dropping of wheel *l* (see fig. 3, in which the disk *o* is replaced by a small cotter). The tie-rods can be adjusted by means of the gap *q* and the nut *t*. The forks f_2 and f_3 extend beyond the centre of the wheel *l* forming the arms c_2 and c_3, leaving the same play as in the case of wheel *a*.

The falling over of the bicycle is prevented by a simple lateral support, a well-known device. The flange of the wheels of this support is not in contact with the rail head, so that the frictional resistance of the wheel is but small. The flange is only provided as a precaution if one of the wire ropes between the side wheel and the frame of the bicycle or the guide wheel p_1 were to break. Each rope is provided with a turn-buckle in order that the tension may be adjusted so that the bicycle has a slight list towards the middle of the track (fig. 4).

After the guide wheels and the lateral support have been folded into the position indicated by the dotted lines in figure 1, the bicycle can be used on any ordinary road (fig. 5).

In the actual mechanism made there are several simplifications. Experiment has shown that the flanges on the guide wheels do not require to be adjustable. Double-flanged guide wheels, adjusted for rail heads 72 millimetres ($2\ ^{13}/_{16}$ inches) wide, can be used without readjustment on rail heads 58 millimetres ($2\ ^{9}/_{32}$ inches) wide. Moreover the gaps *q* are not required and special adjustment of stops *e* is not necessary; it suffices if they are secured at a definite mark, to suit the usual pressure in the rubber tire.

The same device can also be applied, with but little modification, to ordinary motor cars such as are used on high-roads (see figs. 6 and 7). As each axle is sup-

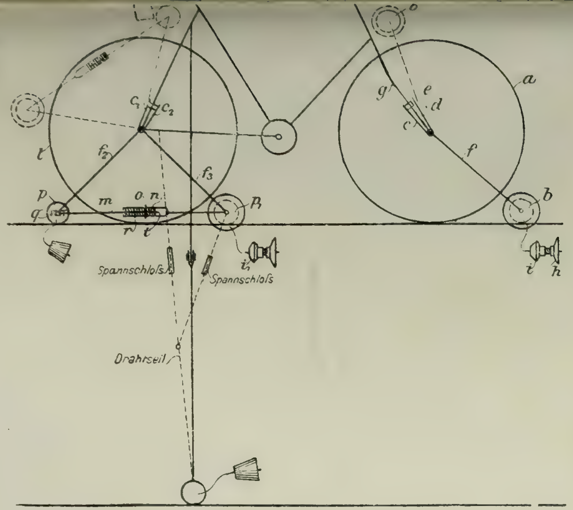

Fig. 1.

Explanation of German terms : Drahtseil = Wire rape.
Spannschloss = Turn-buckle.

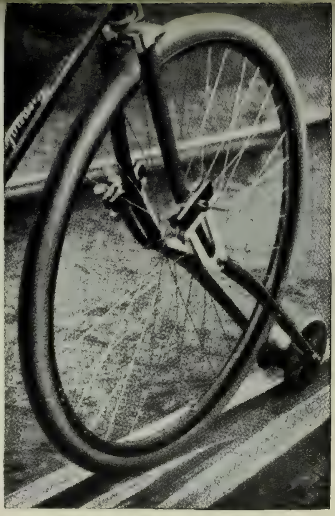

Fig. 2.

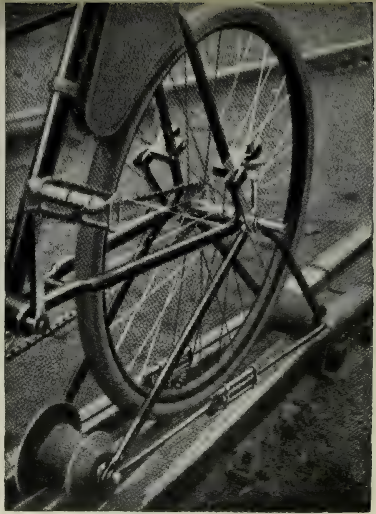

Fig. 3.

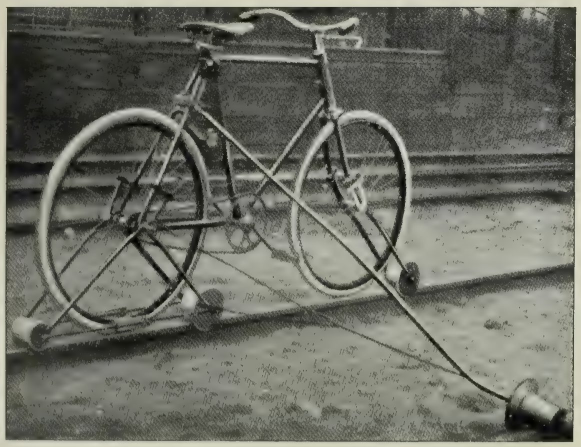

Fig. 4.

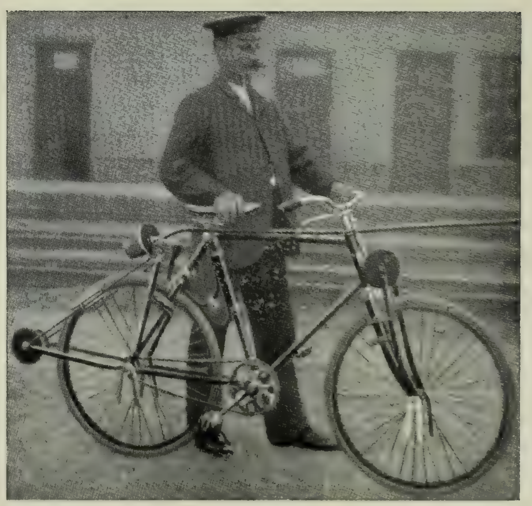

Fig. 5.

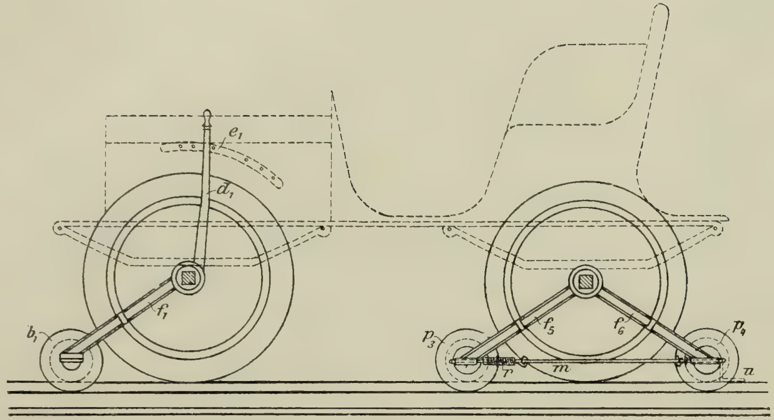

Fig. 6.

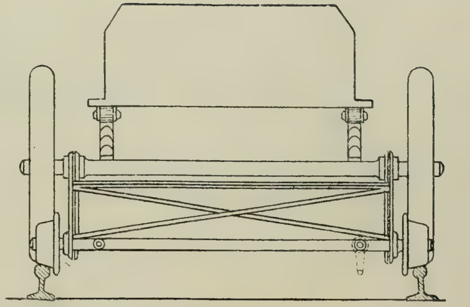

Fig. 7.

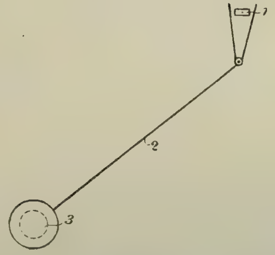

Fig. 8.

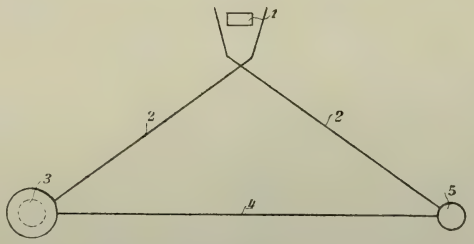

Fig. 9.

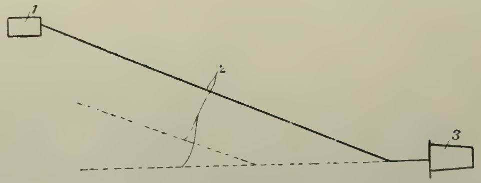

Fig. 10.

ported at both ends and the tires are sufficiently wide to make it unnecessary to take any notice of increases in the gauge, the outer flanges *i* of the guide wheels are not required. As the axle is guided on one side only, the arm *c* is not required, whereas the arm d_1, which is rigidly connected with the support f_1 (which carries the wheel b_1), is elastically pressed against e_1, so as to make it difficult for the two wheels b_1 to mount the rails; without however interfering with the springiness of the pneumatic tires.

The more heavily loaded back wheels are guided by the wheels p_3 and p_4 which are supported by the frames f_5 and f_6, which can be folded upwards. The cranked handle *u* is provided for bringing them into place.

The addition of the new mechanism increases the weight of the bicycle by about 8 kilograms (17 lb.).

Front wheel (fig. 8) :

$$2 \times 150 + 2 \times 450 + 600 = 1{,}800 \text{ grams } (3{\cdot}968 \text{ lb.});$$

Back wheel (fig. 9) :

$$2 \times 150 + 2 \times 700 + 600 + 2 \times 580 + 450 = 3{,}910 \text{ grams } (8{\cdot}620 \text{ lb.});$$

Lateral support (fig. 10) :

$$300 + 1{,}070 + 530 = 1{,}900 \text{ grams } (4{\cdot}189 \text{ lb.});$$

Total : 1,800 + 3,910 + 1,900 = 7,610 grams (16·777 lb.).

The new cycle is a great improvement on the existing railway cycles.

It is so light, that the cyclist can easily lift it on to or off the track at any desired point. It may consequently be confidently expected, that in spite of the more extended use of these railway cycles, the traffic will be endangered less. The new bicycle can be sent anywhere just as easily as any ordinary bicycle. It runs as safely on the rails as the existing railway cycles, but is quicker, easier to work and more comfortable, as pneumatic tires are used, just as on highways. At the same time, it is less expensive than the existing railway cycles; as most of the gangers and also of the platelayers already possess an ordinary cycle, the only expense to be incurred is that of the extra parts.

That it is possible to use the railway cycle in question also on highways is a great advantage, particularly when new lines are being built or when by an accident some of the track has been destroyed, as if there are any sections where the cycle cannot be used on the rails, it can be used on the permanent way or on the nearest highway. Any platelayers living at a distance from the section they are at work on are able, by means of this cycle used on highway and on track, to do the necessary journeys quickly.

An ordinary motor car equipped as described above has the same advantages over the power velocipede cars hitherto used (¹). As these are only used for longer journeys, the advantages of smooth running and of being able to run on highways are of

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(¹) *Organ*, 1906, p. 35.

still greater importance than in the case of the cycle. The power cars now used on railways are too heavy and their engines are not reliable. In order to take the car off at level crossings, at least four men are required as the edges of the flanges (and with them the whole weight) have to be lifted over the top of the rail heads; with the new arrangement one man is enough. All he has to do is to unhook the rod *m* (fig. 6) and fold up the guide frames f_5 and f_6; the car can then run off the rails. In order to hook and unhook rod *m*, it is not necessary to turn the handle *u*; all that is necessary is to compress the spring *r* a little by means of the rod *m*. The handle *u* is only used for the original adjustment of the mechanism to suit the height of the axles of the car.

As motor cars for use on the highway have reached a high stage of development, the device described above enables a good and reliable power velocipede car to be obtained. As such a car runs on rails on pneumatic tires and not, as the cars hitherto used, on thin strips of rubber let into the tires, the engine will have a longer life and fail less frequently, and the car will run smoothly without bumping.

On both the motor cars and the cycle the rubber tires will wear very well, as the top of the rails has no sharp edges and oil is almost entirely absent. The possibility of using ordinary cycles and motor cars on railways as well as on highways is a great advantage from the military point of view.

[625 .13]

THE BERNESE ALPINE TUNNEL (LÖTSCHBERGBAHN),

By FRITZ HROMATKA,

ENGINEER.

Figs. 1 and 2, pp. 1256 and 1257.

(*Zeitschrift des österreichischen Ingenieur- und Architekten-Vereines.*)

The question of piercing the Bernese Alps and constructing a more direct line to Milan, centrally placed between the St. Gothard line and the western approaches to the Simplon, was already discussed in the nineties, and many projects were published. The matter became urgent when the Simplon tunnel was opened, and a decision became necessary. This was arrived at and it was decided to construct a line, with steep gradients, from Frutigen to Brieg, with a tunnel through the Lötschberg, and to operate this line electrically from the beginning.

The Lötschberg committee exhibited the plan of the line, and many particulars in connection, at the 1906 Milan Exhibition. We are going to give a description of the line which is going to be constructed, based on this exhibit and on reports and documents which Mr. A. Zollinger, the chief engineer to the committee in question, has been kind enough to supply us with.

Only two valleys are available for a Berne-Brigue line on the north side, namely the Kander valley between Frutigen and Kandersteg and the Simmen valley between Zweisimmen and Oberried; in the first case the line would join the existing Berne-Thun-Spies-Frutigen line and in the second, the Berne-Thun-Spies-Zweisimmen line, or the Gürbe valley line. On the south side, the Lötschen valley gives the best access to the Rhone valley, so as to enable the new line to join the Simplon line at Brigue.

Many different projects were based on these two possibilities provided by nature; these were called Lötschberg lines when the junction was to be in Frutigen, and Wildstrubel lines when it was to be in Zweisimmen. Projects for the former were made by Hittmann and Greulich, with steep gradients, of 27 per mil, and by Emch, with gentler gradients, of 15 per mil; while for the latter Beyeler proposed a line with gradients of 13 per mil. The height, and consequently the length, of the chief tunnel, naturally varied with the gradient; with the Lötschberg lines its length was to be about 13 kilometres (8 miles) in the case of the steeper gradients and about 20 kilometres (12·4 miles) in the case of the gentler gradients.

The Lötschberg committee, in order to obtain a definite notion of the cost, commissioned a French-Swiss company to work out definite projects, and to make an estimate of the cost after surveying the ground and carefully examining the more difficult sections; two projects for the Lötschberg line (Frutigen-Brigue), one with steeper and one with gentler gradients, and one for the Wildstrubel line (Kehrsetz-Brigue) were to be examined. Both the Lötschberg lines considered by the company branch off at Frutigen and cross the Kander at Tellenburg; then come the loops in order either to attain the upper level of the Bühlstutz at Kandersteg or to reach the entrance of the long tunnel at Mittholz. The south end of the tunnel is in the Lötschen valley, either at a higher or lower level according to the length of the tunnel, the line in both projects crossing the Lonza and then at first going along the east side of the Lötschen valley. It then turns through an angle of 90° and gradually descends into the Rhone valley, along its north side, till it reaches Brigue.

The projected and examined Wildstrubel line branches off, on the north side, at Kehrsetz, a station on the Gürbe valley railway. It then gradually ascends along the west side of the Gürbe valley to Blumenstein; here a tunnel 8,020 metres (4 miles 1,730 yards) is required to pierce the Stockhorn range. The other end of this tunnel is at Bunschen; the line then goes along the west side of the Simmen valley to Zweisimmen and then along the bottom of the valley to the north entrance of the chief tunnel which is 13,520 metres (8 miles 705 yards) long. The south end of the tunnel is in the Rhone valley, and gradually descends along the north side of it till it reaches the bottom of the valley at Brigue.

Particulars as to gradient, length, height and cost are given in the following table.

—	Lötschberg, Frutigen, Brigue.		Wildstrubel, Kehrsetz, Brigue.
	I	II	
Steepest gradient	33 per mil.	15·1 per mil.	15 per mil.
Smallest radius of curves	300 metres. (15 chains.)	300 metres. (15 chains.)	300 metres. (15 chains.)
Total length	**55,990** metres. (**34** miles **1,393** yards)	**57,200** metres. (**35** miles **955** yards.)	**111,425** metres. (**69** miles **418** yards.)
Height, north entrance of great tunnel	1,200 metres. (3,937 feet.)	972 metres. (3,189 feet.)	1,113 metres. (3,652 feet.)
Height, south entrance of great tunnel	1,223 metres. (4,013 feet.)	976 metres. (3,202 feet.)	1,080 metres. (3,543 feet.)
Length of great tunnel	**13,695** metres. (**8** miles **897** yards)	**21,050** metres. (**13** miles **140** yards.)	**13,520** metres. (**8** miles **705** yards.)
Length of other tunnels	12,025 metres. (7 miles 830 yards.)	8,195 metres. (5 miles 162 yards.)	22,250 metres. (13 miles 1,453 yards)
Total cost of construction (1)	86,513,600 francs. (£ 3,460,544)	114,714,660 francs. (£ 4,588,586.)	130,742,580 francs. (£ 5,229,703)
Cost of great tunnel, included in last item . . .	40,729,700 francs. (£ 1,629,188)	70,037,450 francs. (£ 2,801,498)	42,285,500 francs. (£ 1,691,420)

(1) Including the electric installations, but excluding the power station.

All the projects are for single-track lines, except as regards the chief tunnels; in the case of the tunnels up to 14 kilometres (8·7 miles) in length 6 kilometres (3·73 miles) are to be double track, and in the case of the 21 kilometre (13 mile) tunnel, the whole is to be double track. It may be added that the estimated time for carrying out the work was eight and a half years in the case of Lötschberg II, and five and a half years in the case of the other two projects.

Taking as their basis these three projects and their estimated cost, the Lötschberg committee then instructed Mr. A. Zollinger, their chief engineer, to determine which was the best plan, and after the said plan had been approved, to proceed to work out the details of the project.

Mr. Zollinger, taking into consideration all the circumstances and more especially the fact that the proposed line would not only be a section on the route Paris-Genoa, but would also be used for tourist traffic, and consequently should not be too far west of Interlaken, the tourist centre of the Bernese Oberland, decided in favour of the Lötschberg tunnel. He therefore recommended the line proposed in project I as being the only suitable one, but with the modification that the steepest gradient (as on the St. Gothard railway) must not exceed 27 per mil.

The year 1906 was utilized for making the detailed surveys required.

In figures 1 and 2 we show the plan and the profile of the Lötschberg line finally adopted.

The Kander valley is divided between Frutigen and Kandersteg by a land-slide below the road-serpentines in Bühl into two sections : the Kander between Mittholz and Frutigen, 8·4 kilometres (5·2 miles), has a fall of about 3 per cent, and between the Kandersteg plateau and Mittholz, 2·7 per cent, a fall of about 5 per cent; up above the fall is 1·2 per cent. The line after leaving Frutigen passes in a curve under the Tellenburg and crosses the Kander; it then continues on the right bank of the Kander. It crosses the highway at Mittholz, forms a loop round the land-slide, ascends the side of the valley and passes under the Felsenburg. Then a second loop is formed round the Konenwald, and the line once more resumes the up-valley direction. Above the road-serpentines at Bühl the line crosses the Kander again and attains the Kandersteg plateau. At kilometre 18·55 (mile 11·53) the line enters the great Lötschberg tunnel, the other end of which is at Goppenstein station in the Valais. The line then descends, reaching the level of the Rhone valley at Brigerbad, and then goes along the right bank of the Rhone to Brigue, which is to be the terminus of the Lötschberg line.

The final project differs from project I in having, owing to the reduction of the maximum gradient to 27 per mil, a total length of 58·800 kilometres (36·54 miles), the length of the great tunnel being 13·735 kilometres (8 miles 941 yards). The greatest height reached is 1,245 metres (4,085 feet), in the middle of the tunnel (as against 1,249 metres [4,098 feet]). When the details came to be worked out it was found that on the south side there was only a section 6 kilometres (3·7 miles) long where the maximum gradient (27 per mil) was necessary; in the case of the other 78 kilometres (48·5 miles) a gradient of 22 per mil sufficed.

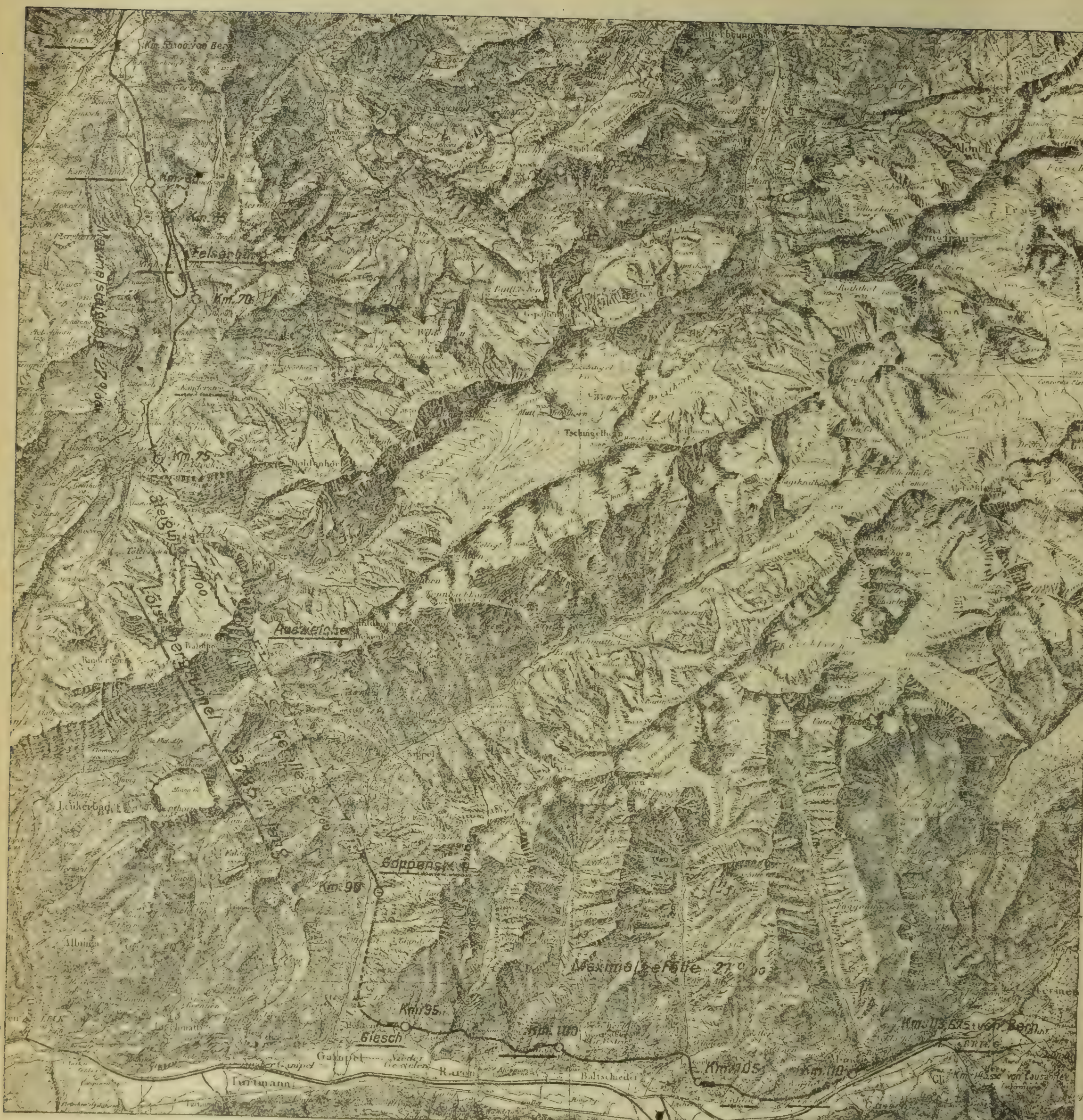

Fig. 1.

Explanation of German terms : Ausweiche = Passing place. — Gefälle = Falling gradient. — Steigung = Rising gradient.

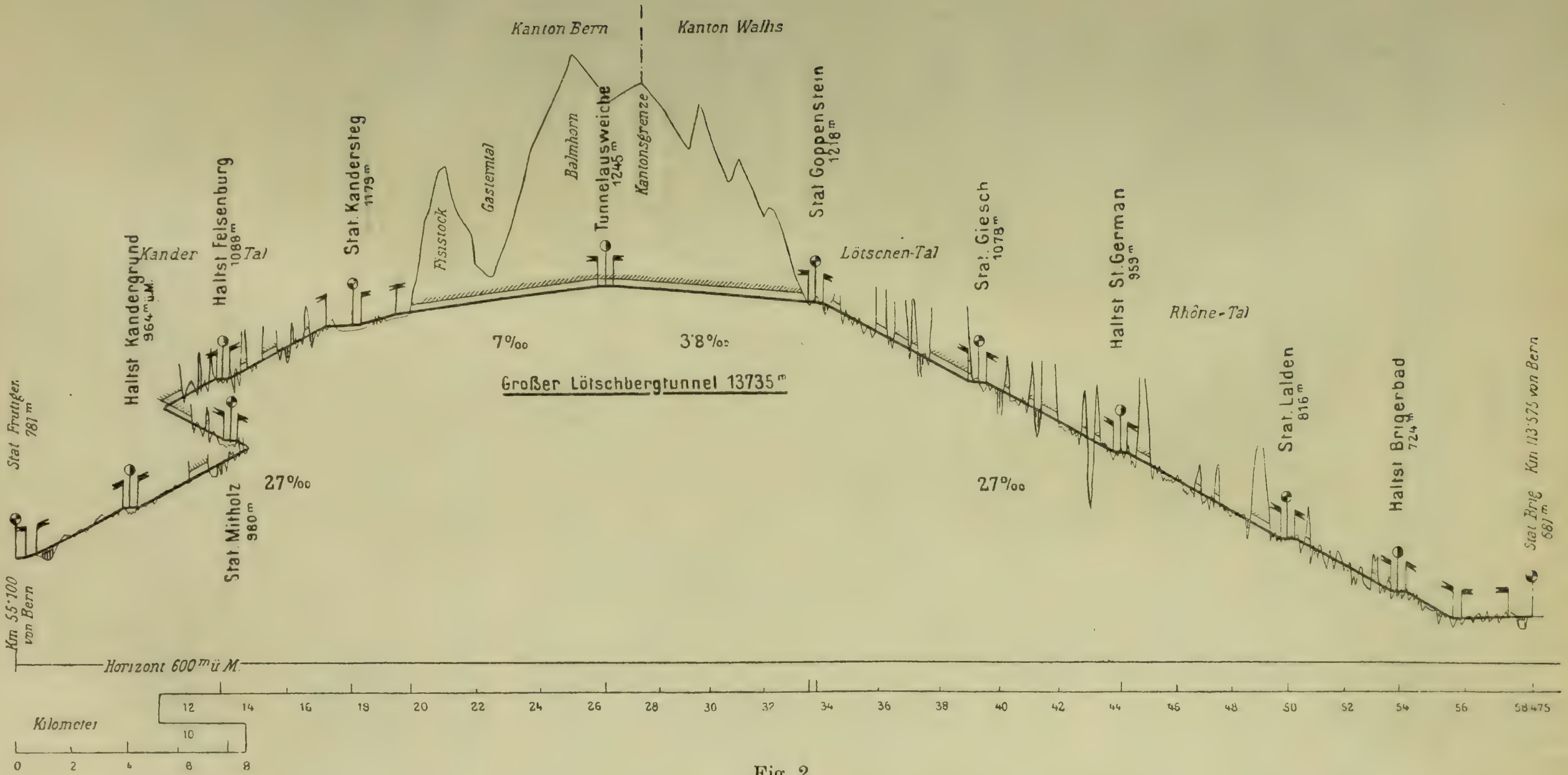

Fig. 2.

Explanation of German terms : Grosser Lötschbergtunnel = Great Lötschberg tunnel. — Tal = Valley. — ü. M. = Above sea-level. — Haltst = Stopping place. — Stat. = Station.

The chief international relations affected are given in the following table. The distances can be further reduced, and that materially, if the Jura is pierced by the proposed Münster-Greuchen line.

—	By the Lötschberg and the Simplon.	By Lausanne and the Simplon.	By the St. Gothard.
From Paris to :			
Milan . . .	817 kilom. (508 miles).	832 kilom. (517 miles).	890 kilom. (553 miles).
Genoa . . .	926 — (575 —).	941 — (585 —).	1,032 — (641 —).
Turin . . .	861 — (535 —).	876 — (544 —).	991 — (616 —).
From Calais to :			
Milan . . .	1,076 — (669 —).	1,128 — (701 —).	1,114 — (692 —).
Genoa . . .	1,185 — (736 —).	1,237 — (769 —).	1,256 — (780 —).
Turin . . .	1,120 — (696 —).	1,172 — (728 —).	1,275 — (792 —).

The projected Lötschberg line is thus between the existing St. Gothard lines and the western approaches to the Simplon; it thus forms part of a through route to Italy, located centrally between the two existing routes.

If sharp gradients are used, the Frutigen-Brigue line is the simplest solution of the question of an approach to the Simplon from the canton of Berne (the original gradient of 33 per mil was reduced to 27 per mil so as to make it possible to use steam traction if necessary). In order however to keep the working expenses down as much as possible in spite of the steep gradients, and also not to charge higher rates than the other competing railways, Mr. Zollinger proposed to introduce electric working from the beginning, so as to obtain an economic arrangement of great efficiency. It has not yet been settled which electric system is to be adopted.

We will consider this subject, including the very interesting calculations of Zollinger as to prospective profits, in some detail as here in Austria the question of electrifying our Alpine railways is also being investigated.

The capital required, with gradients of 27 per mil, is estimated by Zollinger as follows :

For the Frutigen-Brigue line (58·8 kilometres [36·54 miles]) and for purchassing the old Spiez-Frutigen line (12·2 kilometres [7·6 miles])	80,427,550 francs (£3,217,102).
Rolling stock and electric installation (power stations included) for 71 kilometres (44 miles)	4,525,000 — (£181,000).
Cost of promotion and expenses	4,407,900 — (£176,316).
Organization of traffic.	239,550 — (£9,582).
Total . . .	89,600,000 francs (£3,584,000).

Of this amount 21,000,000 francs (£840,000), the amount covered by the subventions, need not be taken into consideration when calculating the interest, so that the capital on which interest is to be paid only amounts to 68,600,000 francs (£2,744,000). The railway will only have to see to its own electrical equipment proper, as the supply of the power required (which involves the necessary extension of the existing power station) is reserved to the Kander and Hayneck stations of the Berne Elektrizitätswerk, as the Berne state is the chief owner of this, the largest electric supply company in its territory.

In the figures given above 63,732 francs per kilometre (£4,102.12*s.* per mile) of line are included for the electric equipment and the electric locomotives; but the central stations are not taken into consideration.

In order to determine the amount of traffic to be expected when the line was opened, the figures determined by Mr. Teuscher, State Councillor, for 1902 were taken as basis, and 4·5 per cent added in the case of the passenger traffic and 3 per cent in that of the goods traffic (the mean annual increase recorded on the St. Gothard line) for each year up to 1914, the year in which the line is to be opened. This gives increases, for the twelve years, of 54 and 36 per cent respectively. Consequently:

1° Passenger traffic	277,000 + 149,580 = 426,580 passengers.
2° Goods traffic.	500,000 + 180,000 = 680,000 tons.

In calculating the prospective profits an average rate of 5·3 centimes (0·819*d.* per mile) is assumed for the passenger traffic and of 6·5 centimes (1·020*d.* per English ton-mile) for the goods traffic (1), and the usual additional amounts are assumed for luggage and cattle transport.

Taking the length operated, Spies-Brigue, as 71 kilometres (44 miles), this gives the following receipts:

Passenger-kilometres: 426,580 × 71 × 5·3 . .	1,605,220 francs	(£64,208.16*s.*).
Luggage, 10 per cent of above item	160,522 —	(£6,420.18*s.*).
Goods, ton-kilometres: 680,000 × 71 × 6·5 . .	3,138,200 —	(£125,528. 0*s.*).
Cattle, 6 per cent of goods	188,292 —	(£7,531.13*s.*).
Miscellaneous, 5 per cent	257,766 —	(£10,310.13*s.*).
Total. . .	5,350,000 francs	(£214,000. 0*s.*).

This amount of traffic corresponds to about 963,280 train-kilometres (598,900 train-miles); but comparison with the St. Gothard traffic makes us think this figure is too high. In 1905, the St. Gothard had 2,986,600 ton-kilometres per kilometre of line: the traffic assumed by Zollinger for 1914 would correspond to 2,818,000 ton-kilometres. Even the estimate of 2,409,840 ton-kilometres, made subsequently by Mr. Thomann, seems to us still improbable.

It is indeed true that the St. Gothard Railway in its statistics gives no separate figures for its main line (Immensee-Chiasso, 200 kilometres [124 miles]), and consequently the density of traffic appears reduced if the figures are applied to the whole system (276 kilometres [172 miles]); and we also agree with Mr. Zollinger in thinking that soon there will be as much traffic on the St. Gothard as it can possibly accommodate, and therefore provision must now already be made for new ways to

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(1) On the St. Gothard Railway the receipts in 1905 were 6·12 centimes per passenger-kilometre (0·946*d.* per passenger-mile) and 7·17 centimes per ton-kilometre (1·125*d.* per English ton-mile).

Italy. But it must not be forgotten that in spite of this, the Lötschberg line can scarcely hope to get as much traffic as the St. Gothard, as the latter has that very industrial country Germany behind it. And now — to make a small digression — the electrification of the St. Gothard is being considered, so as to enable it to accommodate more traffic; but attention must be drawn to the fact that a sum of about 10 million francs (£400,000) will be required for the simultaneous amortization of the locomotive stock, and this is a heavy burden on the electrification.

The Lötschberg line has naturally a great advantage by starting as an electric line; all the more so as it will have to pay for power at the rate of 2 centimes (0·192*d.*) per kilowatt per hour, whereas for instance on the Valtelline line the power station generates the same amount of power at a cost of 3·1 centimes (0·298*d.*).

Mr. Zollinger estimates the working expenses at 2,460,000 francs (£98,400), which would give for this electric line a coefficient of working of 46 per cent. The St. Gothard line which works under similar conditions, but uses steam traction, has a coefficient of working of 57·1 per cent.

Consequently, if we assume the ratio of receipts to expenses to be correct, there is a surplus of 2,890,000 francs (£115,600), that is a rate of interest of 4·2 per cent, or, not considering the subventions, of 3·2 per cent.

Mr. Thomann, engineer, of Zurich, was then commissioned to make an estimate on the cost of electrically working standard-gauge railways with different gradients, on the assumption that the traffic would have the density given above. He took the cases of gradients of 35·15 and 25 per mil, with loads of 120 tons for passenger trains and 240 tons for goods trains; he arrived at the results given in the following table :

—	Lötschberg : Brigue-Frutigen		Wildstrubel : Zweisimmen-Brigue
	35 per mil.	15 per mil.	25 per mil.
Length operated, in kilometres (in miles)	54·9 (34·1)	57·2 (35·5)	66·6 (41·4)
Millions of ton-kilometres (millions of English ton-miles). (per kilometre, 2,409,836 ton-kilometres).	132·30 (80·91)	138·61 (84·77)	153·44 (93·84)
Thousands of train-kilometres (thousands of train-miles)	438 (272)	459 (285)	508 (316)
Speed of a passenger train, in kilometres (in miles) per hour	51/48 (31·7/29·8)	64/64 (39·8/39·8)	64/51 (39·8/31·7)
Speed of a goods train, in kilometres (in miles) per hour	32 (19·9)	32 (19·9)	32 (19·9)
Consumption of energy supplied by power station, in millions of kilowatts per hour	9·42	6·45	8·01
Mean and maximum load, in kilowatts, of :			
North power station	685/2,300	470/1,800	283/2,400
South power station	955/2,900	592/2,200	882/2,700
Working expenses per kilometre, in francs (£ per mile)	28,780 (1,853)	26,420 (1,700)	26,700 (1,719)

These figures would in the first place show that in the case of the steepest gradient the power consumed, measured at the central power station (so that all losses between the switch-board and the tread of the wheel are allowed for), amounts per ton-kilometre to 71 watts (116 watts per English ton-mile) per hour. As a comparison, we may mention that on the Valtelline railway, this consumption averaged 44·5 watts (72·8 watts per English ton-mile) per hour (¹), and on the Swedish State Railway, when an experimental run of a self-propelled car weighing 37·5 tons (36·9 English tons) with four motors, belonging to the Westinghouse Co., was made, it averaged 74 watts (121 watts per English ton-mile) per hour; finally, on an experimental run of the one-phase alternating-current locomotive of the Maschinenfabrik Oerlikon, it amounted to 41 watts (67 watts per English ton-mile) per hour. The consumption of energy allowed for in the calculations is thus ample.

Moreover, the cost of 1 train-kilometre would be 3·61 francs (4*s.* 7·772*d.* per train-mile), and of 1,000 ton-kilometres 1·19 francs (1*s.* 6·68*d.* per 1,000 English ton-miles); these figures certainly seem to us a little too low. (Unfortunately details as to working expenses are not given in the documents at our disposal.)

If we now by way of comparison take the Valtelline line, we find the cost of 1,000 ton-kilometres (per 1,000 English ton-miles) to be made up as follows:

1° Power station : staff, materials, maintenance	0·35 lira (0*s.* 5·494*d.*).
2° Cables and conductors : staff, materials, maintenance	0·56 — (0*s.* 8·791*d.*).
3° Rolling stock : amortization, maintenance and pay of train staff	1·06 — (1*s.* 4·639*d.*)
Total per 1,000 ton-kilometres (per 1,000 English ton-miles)	1·97 lira (2*s.* 6·924*d.*).

The 1905 average on the Austrian State Railways, all lines, was 3·50 kronen (4*s.* 9·138*d.* per 1,000 English ton-miles); in the Innsbruck district (Arlberg), including no local lines, 4·03 kronen (5*s.* 5·772*d.* per 1,000 English ton-miles); on the St. Gothard Railway, on account of the high price of coal, 7·45 francs (9*s.* 8.945*d.* per 1,000 English ton-miles). Baron von Ferstel, the chief civil engineer of the Railway Ministry, in estimating the cost of the electrification of the Austrian State Railways, arrives at the amount of 95,000 kronen per kilometre (£6,360 per mile) of railway, on the assumption that the mono-phase alternating-current system will be used, and including the cost of the power stations, where water-power is to be used.

Now if we wish to estimate the effect of the immediate introduction of electric working on the Lötschberg line, we may take on the one hand the St. Gothard Railway, and on the other the Valtelline line, for purposes of comparison.

The amount of traffic assumed by Mr. Zollinger, 2,818,000 ton-kilometres per kilometre of railway, was attained in 1901 on the St. Gothard Railway; in this year the cost of traction amounted to 17,780 francs per kilometre (£1,144·11*s.* per mile) of railway.

On the Valtelline line 1,000 tons gross cost 1·97 francs (2*s.* 6·924*d* per 1,000 English ton-miles); on the Wien-Anspang line, which is operated by steam and has about the same amount of traffic, they cost 3·996 kronen (5*s.* 5·929*d.* per 1,000 English ton-miles). The ratio is thus 47 per cent in round figures. Now if we assume the same ratio to apply to the case of the St. Gothard, instead of 17,780 francs (£1,144·11*s.* per mile) we would have 8,857 francs (£570.3*s.* per mile) in the case of electric traction.

(¹) Eugen Cserháti, *Zeitschrift des Vereines deutscher Ingenieure*, 1905.

To this we must add 4 per cent, interest on the capital required for the alteration, so that the total cost of electric traction would be 8,857 + 3,800 = 12,657 francs (£814.15*s.* per mile) as against 17,780 francs (£1,144.11*s.* per mile), the cost of steam traction; the resulting economy would thus amount to about 28 per cent.

This saving of about 5,000 francs (£322 per mile) in working expenses per kilometre (we are quite aware that the cost of traction on steep gradients must be higher than on the Valtelline line, but in the absence of any other comparison, the percentage ratio is the best approximation available) if applied to the whole Spies-Frutigen line, 71 kilometres (44 miles) long, corresponds approximately to a saving in capital expenditure of 8·8 million francs (£352,000) a figure which throws such a striking light on Mr. Zollinger's proposal that further consideration of it seems unnecessary.

The electrificaton of stardard-gauge railways in countries where water-power is available, but no coal, would be advisable from the national economic point of view, even if steam traction and electric traction cost the same; for then the sums which have to be paid to foreign countries for coal would be reduced (1). But as the Valtelline line figures prove, the cost of traction which amounts on the Austrian State Railway to 26·2 and on the St. Gothard Railway to 41·7 per cent of the total working expenses, is materially reduced; it therefore becomes all the more necessary, particularly in the case of all mountain railways where working expenses are high, to electrify the lines if they are looked on as ordinary investments and dividends are to be paid on the capital invested.

In Austria, the electrification of our Alpine lines has not yet progressed beyond the stage of being projected and of experiments being made, whereas the construction of the Lötschberg line, where the conditions are very similar to those on our Alpine lines, has been actually commenced. In not many years the results generally and also the financial results will be known, and it is consequently only natural that all the particulars ascertained about the Lötschberg line will be considered with the greatest interest by those in favour of the electrification of the Austrian mountain lines.

In conclusion we wish to express our gratitude to Mr. A. Zollinger for his kindness in supplying us with the papers and documents on which this article is based.

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(1) The five chief railways of Switzerland pay over 10 million francs (£400,000) to other countries every year.

MISCELLANEOUS INFORMATION

[656 .253]

1. — Track circuits at Guildford; London & South-Western Railway.

Figs. 1 and 2, p. 1264 and 1265.

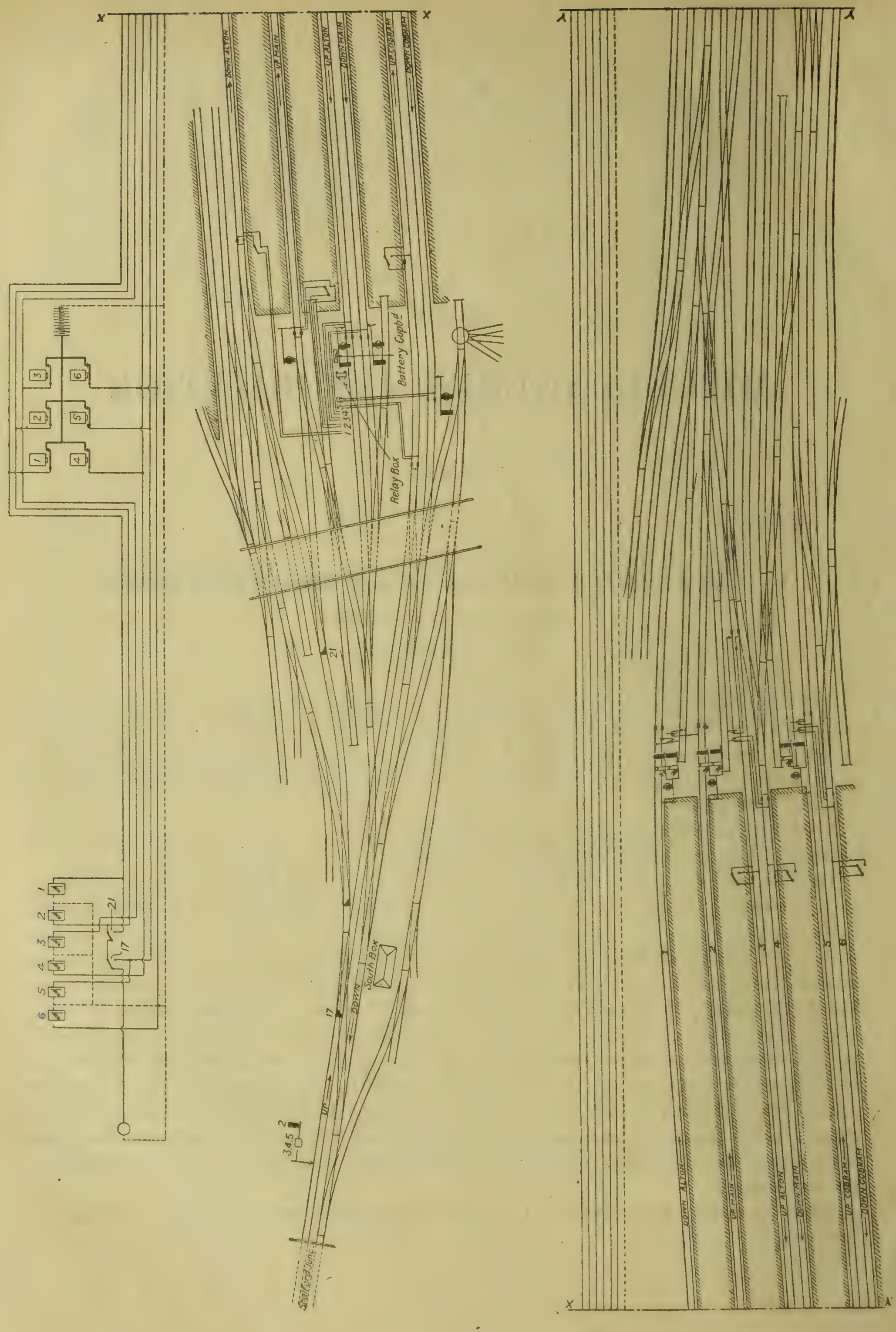
(*The Railway Engineer.*)

Guildford Station is protected by two signal-boxes — the South box at the London end and the yard box at the Woking end, but as the signalmen in these boxes have a very indifferent view of the lines in the station it was decided to equip these lines with " track-circuits ", as shown on figure 1, and the work was carried out by the British Pneumatic Railway Signal Company, Limited, Westminster.

Rotary slots, O'Donnell, have been fixed on the signals at each end of the station, with indicating discs on the same wires in the signal-boxes.

The O'Donnell rotary slots are illustrated by figure 2. On the spindle of the signal-arm, is fixed a circular box with a lug 15 at the side to which the upright signal rod is attached instead of to the arm casting. On the spindle is also fixed a disc 12, and the box is rotatively mounted on the disc, and an electric clutch device is also mounted thereon. This consists of an electro-magnet 16, carried on bracket 17, and a pawl 19 which fits into a slot 20 in a recess in the box and is held there by the cranck 22. Should the magnet 16 not be energised, the pawl 19 would be forced out of the recess when the signal rod — connected at 15 — was raised, and therefore the box would revolve without turning the disc or, consequently, the spindle. But if the magnet be energised, the armature 27 of the lever 23 would be attracted. This lever works on the same spindle 25*a* as the shorter lever 24, which has a lug 24*a* engaging with the crank 22, so that the magnet, being energised, causes crank 22 to be held, and this keeps the pawl 19 in the recess of the box so that the latter, being turned, causes the disc 12 and the spindle to be turned and the arm lowered.

When the magnet is de-energised, the pawl is released and the box returns to normal by its own weight.


X
X
Y
Y
DOWN ALTON
UP MAIN
UP ALTON
DOWN MAIN
UP COBHAM
DOWN COBHAM
Battery Cupbd.
Relay Box
1 2 3 4 5 6
South Box
DOWN
UP
21
17
3,4,5
2
Shalford Junc.
1
2
3
4
5
6

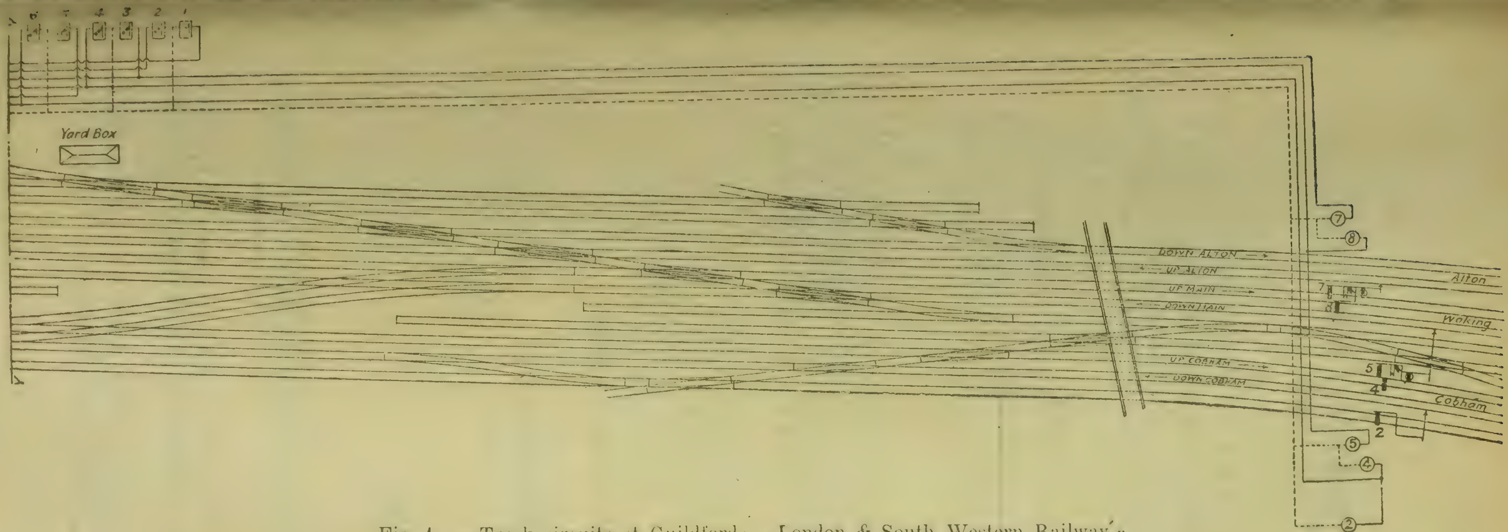


Fig 1. — Track circuits at Guildford ; « London & South Western Railway ».

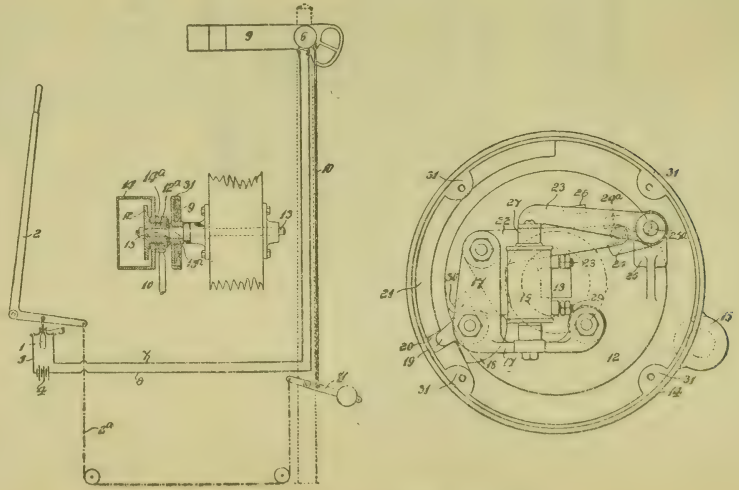


Fig. 2. — O'Donnell's rotary slot.

[656 .253]

2. — Line circuits established at the Brussels " Nord " station of the Belgian State Railways.

Figs. 3 to 7, pp. 1266 to 1269.

At the commencement of 1906, the Belgian State Railway established at Brussels " Nord " terminus, an electric arrangement to prevent signalmen from admitting a train on to a platform siding which was already occupied. For this purpose the siding was electrically insulated. At one of its extremities, the two rows of rails were connected to the two poles of a source of electricity of 6 volts; at the other extremity a relay *b* was interposed. In the circuit, there are inserted a current-economising circuit-breaking switch *a*, manipulated by hand by the signalman, and a resistance of 10 to 12 ohms. The source of electricity is formed by three Tudor accumulator cells; the relay *b* and the resistance are arranged in the cabin over the central electric switch-point and signal controlling apparatus.

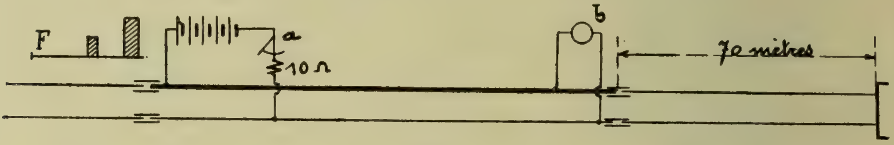


Fig. 3.

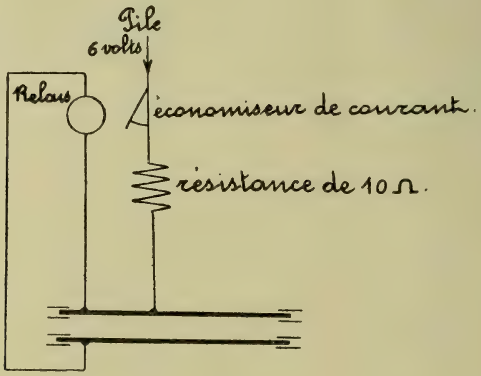


Fig. 4.

Explanation of French terms : Économiseur de courant = Current economising switch. — Pile = Battery. Relais = Relay. — Résistance de 10 Ω = Resistance of 10 ohms. — 6 volts = 6 volts.

When the line is free, the relay cuts off the circuit which couples the home signal placed at the end of the platform as soon as the current economising switch *a*, is manipulated. The signal can then be set at " clear ".

On the other hand, if one or more carriages occupy the siding, their wheels put the relay in short-circuit, and the circuit which couples the home signal cannot be closed.

The siding circuit ends at a distance of about 70 metres (230 feet) from the buffer stops so as to create a neutral space at the end of the platform, into which isolated vehicles (luggage vans, through-carriages, insulated vans or mortuary carriages, etc.) may be shunted.

By means of a special " route " lever in the cabin, which closes a switch, a second train can, by way of exception, be admitted to a platform siding by counteracting the effect of the short-circuit produced by the first train ; but in that case, it is the shunting signal arm which is placed at " clear ".

The driver is stopped at the distant signal and is thus warned that the siding, into which his train is being admitted, is occupied ; he can therefore slacken his speed and enter cautiously.

The system we have just described, is being carried out on all the platform sidings of the Brussels " Nord " station where it has given very good results. It will be extended at all the arrival platform sidings at large stations where signalling is done by electricity, when such sidings are at a sufficient distance from the cabin.

On the same principle, there have been established at the Central Station at Antwerp and Ghent " Sud " Station, insulated sections of rails intended to prevent collisions through fouling at crossing-points adjoining the departure platform sidings, which are frequently encumbered with very long trains, and are at a distance from the electric signal cabins.

With a view to simplicity and economy, line circuits are not employed, but an arrangement resembling that of the " insulated rail ", taking the place of the " locking bar " and acting with intermittent current, is adopted. This arrangement has been described in the *Bulletin of the Railway Congress* (August, 1904, p. 679).

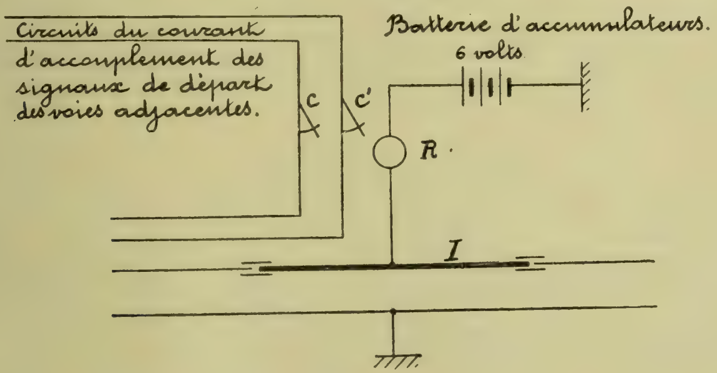

Circuits du courant d'accouplement des signaux de départ des voies adjacentes.
Batterie d'accumulateurs.
6 volts
c
c'
R
I

Fig. 5.

Explanation of French terms : Batterie d'accumulateurs = Accumulator battery. — Circuits du courant d'accouplement des signaux de départ des voies adjacentes = Coupling circuits of the starting signals of the adjacent tracks.

Figure 5 shows the action of the system. When a vehicle occupies the insulated rail I, the armature of the relay R acts upon the contacts, c, c', thereby breaking the coupling circuits of the starting signal on the adjacent lines, which give access to the dangerous zone.

Figure 6, with the dimensions enlarged to make things more clear, shows the installation fitted up in the Ghent-Sud station ef which figure 7 gives a general view.

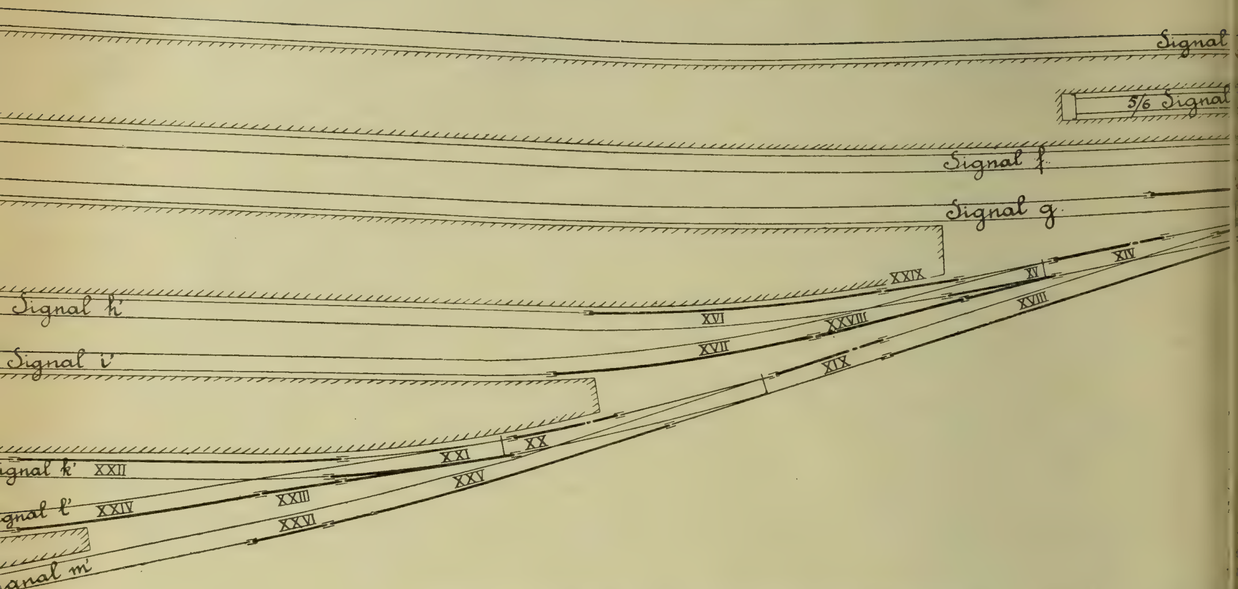


Fig. 6. — Installation of line circuits for preventing collisions through fouling of poi

Key :
= Insulated rail acting on the rel
= Insulated rail intended for lock
= Combination of the two precedir

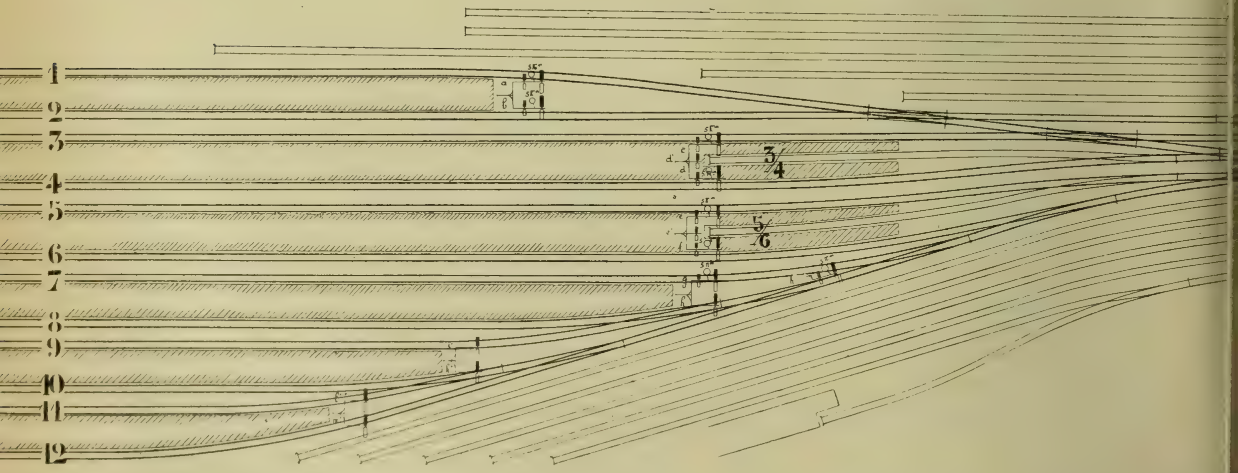
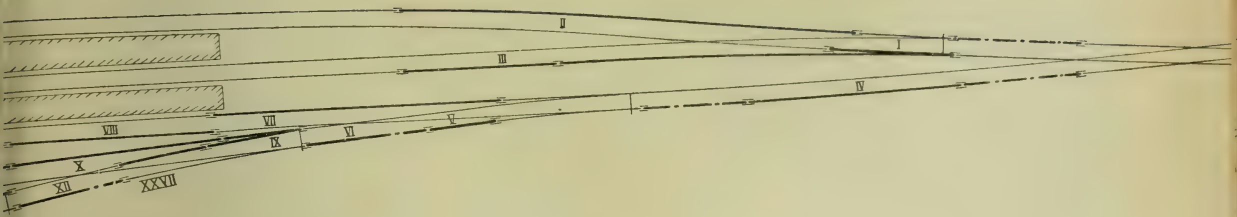


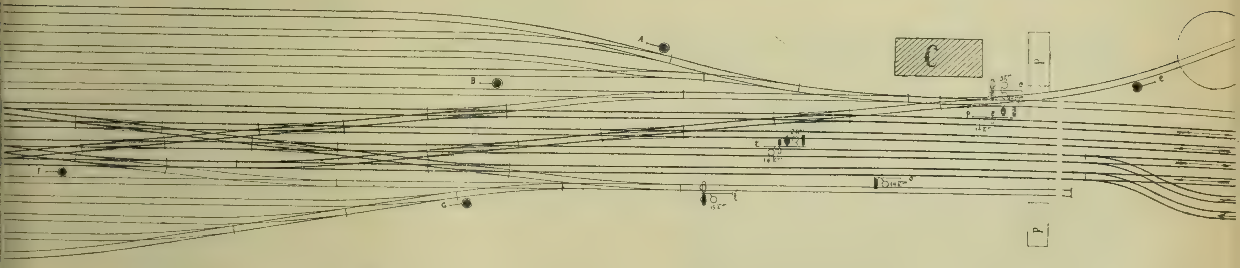
Fig. 7. — General

Key : C = Electric si



rtion of the Ghent-Sud Station, situated at a distance from the electric signal cabin.

events lowering the starting signals so as to free the adjacent tracks which give access to the dangerous zone.
sponding switch points, while the latter are being fouled by a vehicle.
ents.



e Ghent-Sud station.

- P. P. = Footbridge.

The subjoined table indicates the rôle of the various sections of insulated rails :

When the insulated rail :	is occupied, the corresponding relay breaks the coupling circuits of the starting signals :	and prevents the departure of a train from the siding
III	*e*	5
II	*e'*	5/6
IV	*e* or *e'*	5 and 5/6
I	*f*, *g* and *h* (*h' i' k' l' m'*)	6 to 12
X, IX, VI, V, XXVII	*f*	6
VIII, VII	*g*	7
XIII, XII, XXVII	*g*	7
XI, X, VII	*h* (*h' i' k' l' m'*)	8 to 12
XVII, XXVIII, XVIII	*h'*	8
XVI, XIX, XVIII, XXIX	*i'*	9
XXVIII, XV, XIV, XXIX	*k' l' m'*	10 to 12
XXIV, XXIII, XXV	*k'*	10
XXII, XXVI, XXV	*l'*	11
XXIII, XXI, XX	*m'*	12

The electric signal cabin (fig. 7) is at a distance of about 350 metres (1,150 feet) from the end of the platform and the arrangement of the lines is such that a long train standing in one of the sidings 5, 6 or 7 may prevent the signalmen from seeing the entrance to the platform sidings 8-12.

L. W.

[656 .253]

3. — Track circuit installation.

Figs. 8 to 10, p. 1271.

(*Great Western Railway Magazine.*)

It having been found necessary to shorten the block section of 2 $^3/_4$ miles between Pangbourne and Goring stations, automatic signals controlled by track circuits have been introduced, thus saving the expense of a signal box and staff.

In the systems of track circuited signals adopted in America and elsewhere, block working is dispensed with, and the signals stand normally at " all right, " being put to the " danger " position by trains and so held until a point some distance in advance of the signals has been passed, the signals then automatically falling back to " all right. " It was, however, felt to be desirable to retain block working and also to adhere to the normal " danger " position for the signals, and the installation has been developed on these lines.

The scheme of the signals is shown in figure 8. The chief features are : 1° The normal position of the automatic signals is " danger " ; 2° the signals are controlled from the signal box in the rear, only being capable of being lowered to the " clear " position when the track circuit ahead is clear ; and 3° block telegraph working is maintained between Pangbourne and Goring.

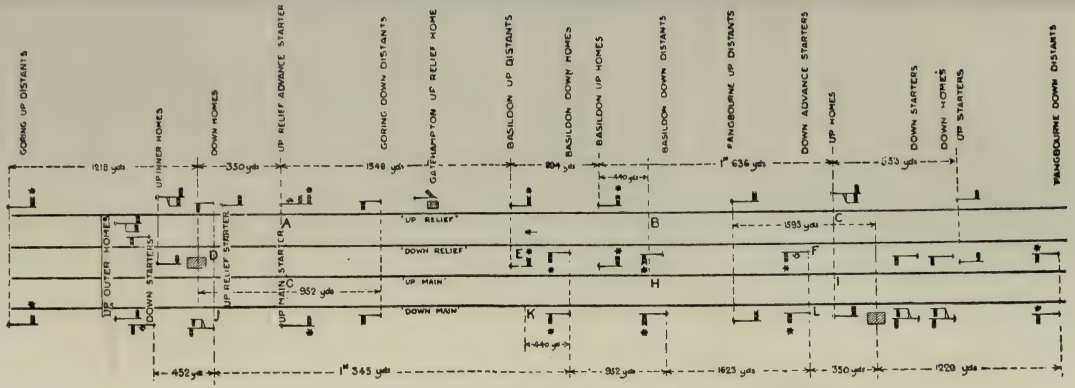


Fig. 8. — Plan of signals at Basildon, between Pangbourne and Goring.

(The up relief distant and advanced starter for Goring can be lowered manually from Goring, providing section A-B is clear. The up main distant and starter for Goring can be lowered manually from Goring, providing section G-H is clear. The down relief distant and advanced starter for Pangbourne can be lowered manually from Pangbourne, providing section E-F is clear. The down main distant and advanced starter for Pangbourne can be lowered manually from Pangbourne, providing section K-L is clear. The Basildon up relief and main, home and distant signals, electrically controlled by Goring, cannot be lowered unless sections B-C and H-I respectively are clear. The Basildon down relief and main, home and distant signals, electrically controlled by Pangbourne, cannot be lowered unless sections D-E and J-K respectively are clear. The signals automatically put to " danger " by the train immediately the first pair of wheels passes the post are marked *. The signals are all replaced to " danger " by means of the track circuit, with the exception of the distant signals for Pangbourne and Goring, which are replaced by treadles.)

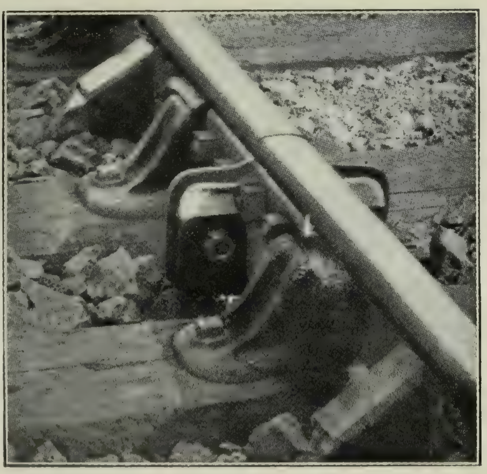


Fig. 9. — Sykes-Johnson insulating rail joint.

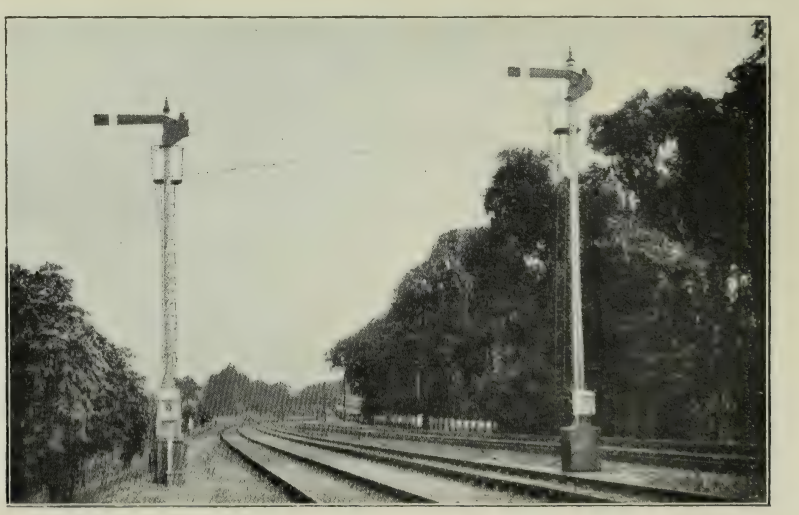


Fig. 10. — Automatic " Home " signals at Basildon, showing boxes containing the disc instruments.

The position of the signals being normally " danger " there is not so much risk of their being frozen down in the " off " position as is the case with ordinary track circuit working, in which the normal position of the signals is " clear. " Further, if the track circuit should fail by reason of the presence of sand insulating the wheels of the vehicles from the rails, or from any other cause, the block telegraph provides a very necessary safeguard — in fact it may be said that, with the system adopted, the track circuit checks the block telegraph working and the block telegraph checks the track circuit.

For dividing the running rails into the various track circuit sections, the Sykes-Johnson type of insulating rail joint, illustrated in figure 9, has been made use of. The signals, which are worked by electric motors — the power for driving which is obtained from primary batteries — were supplied by the Westinghouse Brake Company, and are of the type described in our issue of January, 1906. The class of primary battery used is that known as the " Gordon, " which is of the caustic-soda type.

From the diagram, figure 8, it will be seen that there are two Up and two Down lines, each of which has been track circuited. Automatic Home and Distant signals for all the lines have been provided at Basildon, midway between Pangbourne and Goring, these being worked electrically by the signalmen in charge of the respective lines. Provided the section is clear between his box and the automatic signals, the signalman is able to lower his starting signal for a train to proceed as far as the automatic signals; and if there is nothing on the line between the latter and the signal box in advance, he may, after obtaining " Line clear " on the disc block apparatus, lower the automatic signals, thus allowing a train to pass on to the next station. The Basildon signals and the starting and distant signals at Pangbourne and Goring are put to " danger " by the engine immediately it passes the respective signal posts, and are so held until the train has passed over the track circuited section in advance.

In the event of an engine driver finding the Basildon automatic home signal at " danger, " he must wait one minute and, if the signal is not then lowered, send his fireman to the signal, on the post of which is fixed a box containing a block telegraph disc instrument. Should this indicate " Line clear " the driver may proceed cautiously to the box in advance, but if the disc is showing " Train on line ", he must wait until " Line clear " appears, or an order to proceed is obtained from the signalman in the rear box.

For the information of the signalmen, an indicator is provided in the Pangbourne and Goring signal boxes to show the state of the line to a point a quarter of a mile in advance of the Basildon automatic signals, the indications being respectively, " Track occupied " and " Track clear."

From what has been stated, it will be evident that the installation embraces several features differing from anything of the kind in use elsewhere, and it is believed to combine all that is best in English practice with the advantages of American track circuit signalling.

[625 .252]

4. — New corridor trains; London & North Western Railway.

(*Railway Engineer.*)

For the special service between Euston and the Riverside station, Liverpool, in connection with the American traffic, the London & North Western have lately constructed three corridor trains at the works at Wolverton to the designs of Mr. C. A. Park, M. Inst. C. E., carriage superintendent.

Each train consists of eight vehicles, *viz.* : Three ordinary and two dining saloons, each 65 ft. 6 in. long, one kitchen car and two brake vans, each 50 feet long. The ordinary saloons seat 52 first class, 24 second class, and 24 third class passengers, and the dining cars 51 first class, 24 second class, and 27 third class. The dining cars are in the middle of the train and the first class passengers at one end and the second and third class passengers at the other, so that the meals are served to all classes simultaneously.

The train is entered through wide vestibules at the ends of the coaches.

All the vehicles are provided with electric light except the kitchen car, which carries gas for cooking purposes and is lighted by inverted incandescent gas mantles. The usual means of communication between passengers and driver and guards is provided, and also electric bells between the dining cars and attendants. Special attention has been given to the ventilation and heating arrangements.

The two first class saloons are divided into one large and five smaller compartments. One saloon has three compartments with sofas and chairs and three compartments with chairs only, and the other has two compartments with sofas and chairs and the other four compartments with fixed seats.

The corridor saloon, for second and third class passengers, is provided with fixed seats. Lavatories are provided at each end of the saloons.

The first class dining car has three compartments with loose chairs, two seating 18 passengers and one seating 15, and the second and third class dining car is of the same length, and has also three compartments, two second class for 12 passengers each and one third class for 27 passengers.

The dining cars seat two on one side of the corridor and one on the other. The vehicles are 9 feet wide.

The kitchen car has three compartments, the centre being a long kitchen, 18 ft. 5 1/2 in. by 6 ft. 5 in.

The vans are open throughout, with two pairs of folding doors outwards on each side so as to facilitate dealing with the luggage. The vehicles are 9 feet wide.

[625 .245]

5. — North-Eastern Railway dynamometer car.

Figs. 11 to 15, pp. 1275 to 1277.

(*The Engineer.*)

A dynamometer car has recently been designed and constructed by Mr Wilson Worsdell, chief mechanical engineer to the North-Eastern Railway Company, for the purpose of testing locomotives and rolling stock, with a view to obtaining data which would enable the growing demands for greater speed and haulage to be met, and generally make for increased efficiency.

The body is built on a steel underframe, shaped to take a special spring S (fig. 15) which extends right across the middle of the carriage. This spring consists of thirty selected steel plates, each separated by rollers, so that there is a minimum of friction. The end of the spring adjacent to the draw-bar is provided with rollers R, at each end of the span abutting against fixed

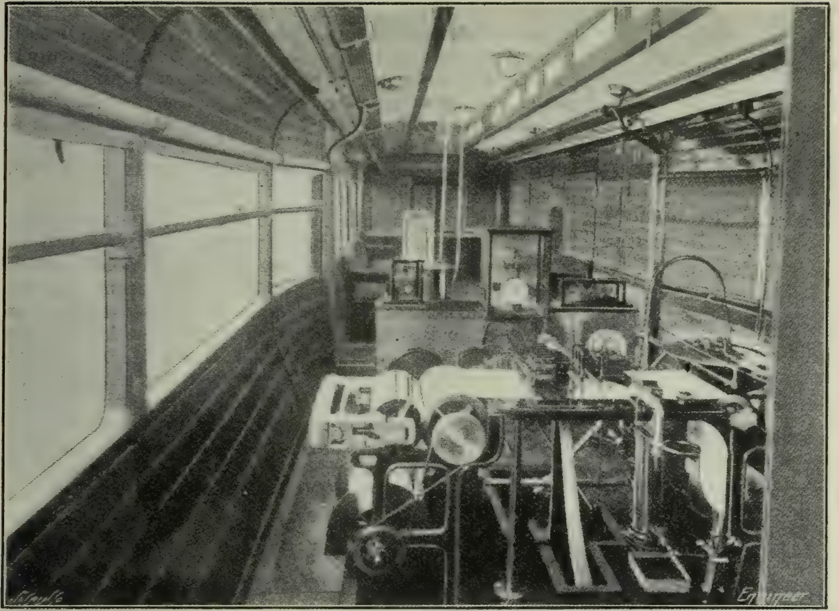


Fig. 11. — Recording apparatus.

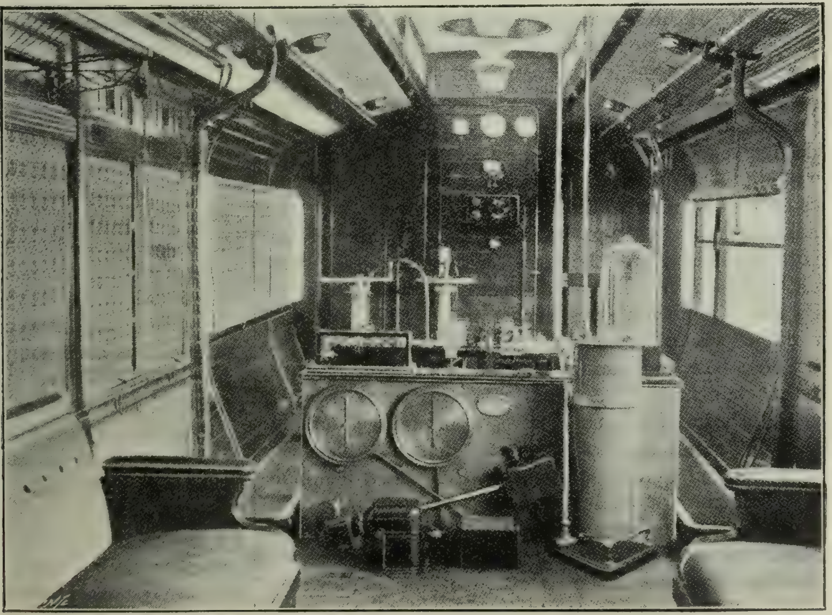


Fig. 12. — Pull and speed dials and wind gauge.

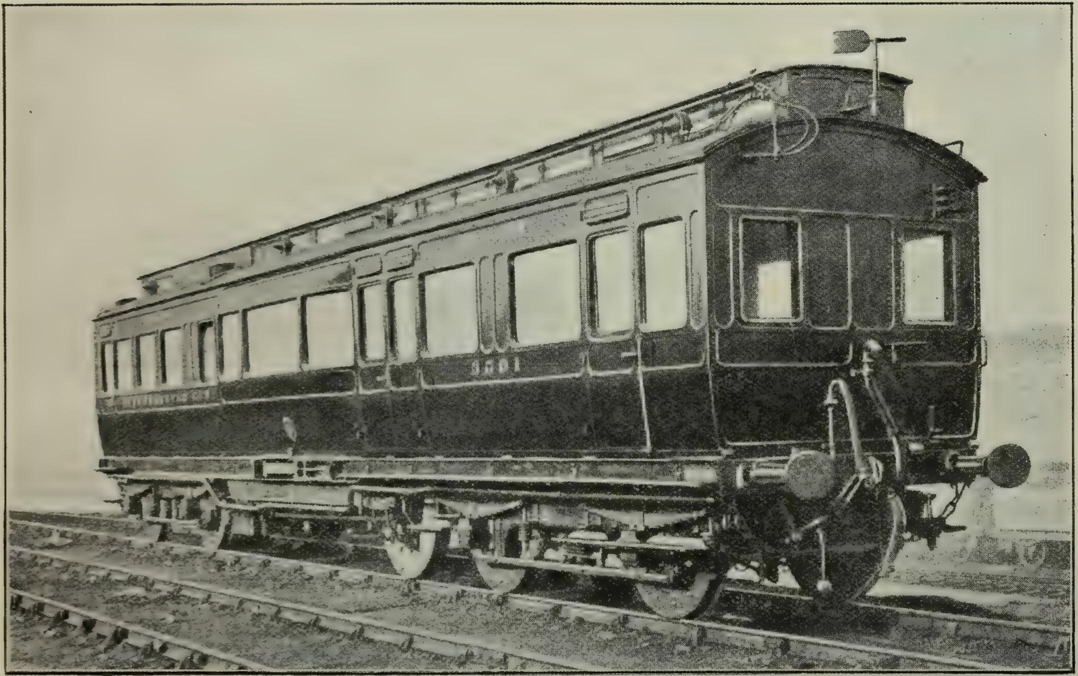


Fig. 13. — Exterior of dynamometer car.

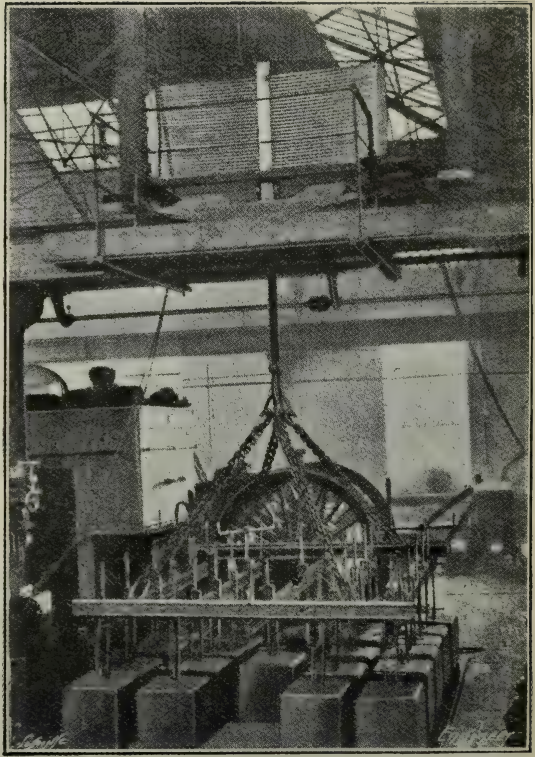


Fig. 14. — Testing the prings.

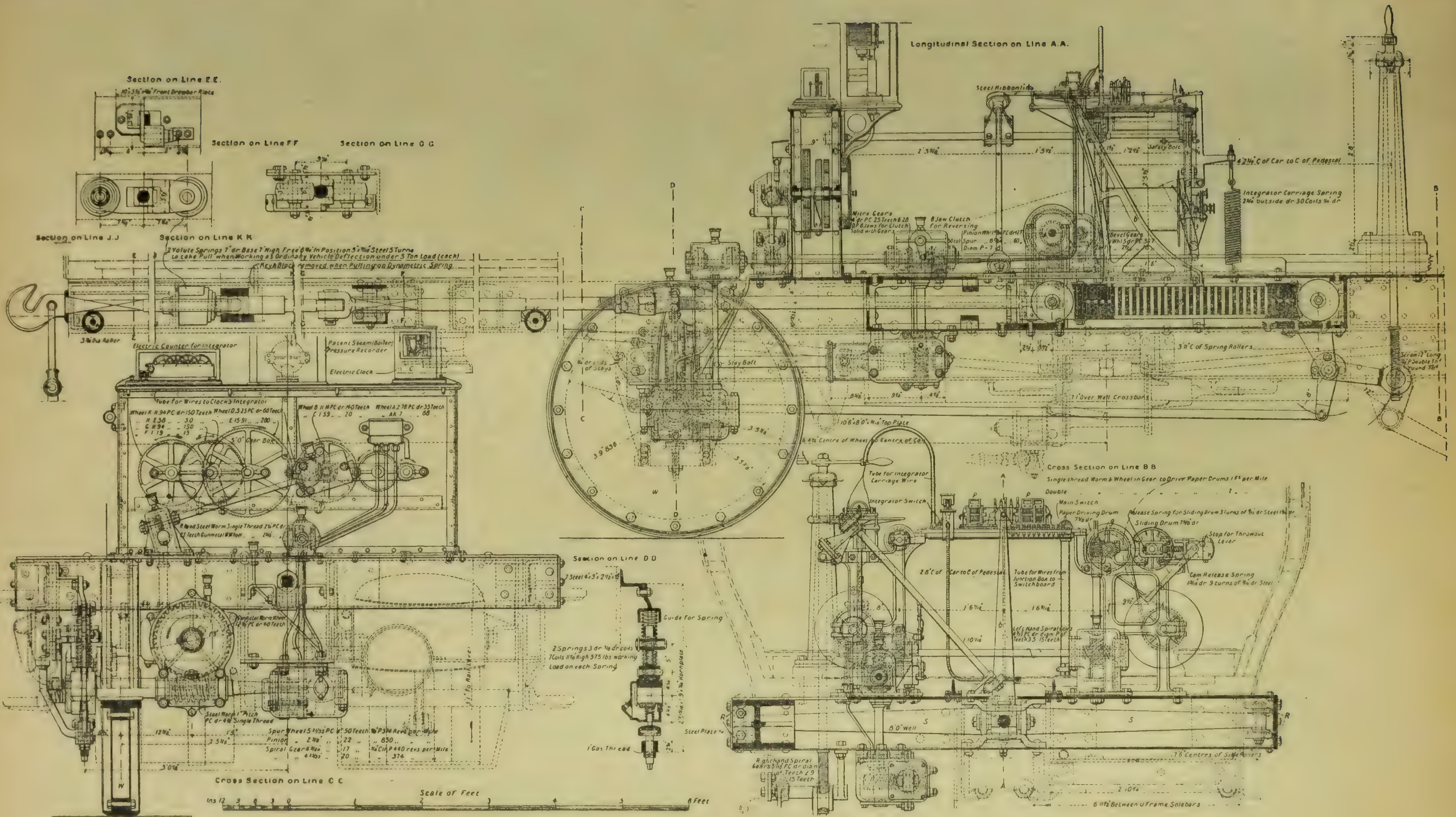

Section on Line E.E.
Section on Line F F
Section on Line G G
Section on Line J.J
Section on Line K K
Longitudinal Section on Line A.A.
Integrator Carriage Spring
Steel Ribbon
Safety Bolt
Mitre Gears
8 Jaw Clutch for Reversing
Bevel Gears
Key & Block removed when Pulling on Dynametric Spring
3' 11" C of Spring Rollers
Stay Bolt
7' 1" Over Well Crossbars
Electric Counter for Integrator
Patent Steam (Boiler) Pressure Recorder
Electric Clock
Tube for Wires to Clock & Integrator
3 3/8 dia Roller
Cross Section on Line B B
Tube for Integrator Carriage Wire
Integrator Switch
Main Switch
Paper Driving Drum
Sliding Drum
Stop for Throwout Lever
Cam Release Spring
Tube for Wires from Junction Box to Switchboard
Section on Line D D
Guide for Spring
1" Gas Thread
Steel Plate
8' 0" Well
7' 6" Centres of Solebars
6' 11" Between U Frame Solebars
Cross Section on Line C C
Scale of Feet
Ins 12 9 6 3 0 1 2 3 4 5 6 Feet
A
B
C
D
R
S
W

Fig. 15. — North-Eastern Railway dynamometer car. — Measuring and recording mechanism.

faces, and from these the pull is transmitted to the train. As the function of this spring is to give an accurate measurement of the pull exerted on the draw-bar, it was essential that the plates composing it should be of the highest quality, and that when buckled together they should be very carefully calibrated. Each plate was tested separately by being placed over supports and loaded until the specified deflection was reached, after which it was allowed to return to a horizontal position by unloading; or, failing in this, was rejected. A uniform rate of deflection was also required. After being put together, the spring was carefully calibrated. The arrangement for testing the spring is shown in the engraving (fig. 14).

A bracket, *b* (fig. 15) is fixed to the buckle of the spring and projects inside the car, and as the spring is deflected, the bracket moves a stylographic pen over a roll of paper, thus drawing a curve of the draw-bar pull The paper is caused to travel over a table by drums driven by a measuring wheel, W, which rolls on the rail, and which can be raised or lowered from within the car at will. This measuring wheel is fitted with a very hard steel tire to minimise wear, and is accurately ground, so that it makes a predetermined number of revolutions per mile. The paper can be made to run at varying speeds by changing the driving gear, *g*, between the measuring wheel and the drums. The speed of the train at any instant is shown in front of the operator by a pointer on a dial. The permanent speed record is given by a pen in electrical communication with a clock, *c*, which thus makes a mark on the travelling roll of paper at two-second intervals; the speed can be read off from this by the aid of a special scale. There are eight of these electro-magnetic pens, *p*, which may be coupled up as required through a terminal board, and thus may be put into communication with any instrument, and by the aid of connections at each end of the car external communication can be made.

The interior view, looking on the instrument table, figure 11, shows the electro-magnetic pens. Underneath the table, may be seen the bracket extending from the spring buckle up to the spindle on which the draw-bar pen is fixed. On the front of the case on the far side of the instrument table, are four dials which show the distance travelled, and above that, looking from left to right, can be seen the clock, boiler pressure recorder, and a meter for registering the work done.

The apparatus at the right side of the instrument table measures the work done, and is on the same principle as a planimeter; the horizontal circular plate moves a proportional distance to that of the train, whilst a frame supporting a small wheel on edge moves across it from the centre a distance proportional to the pull on the drawbar; its revolutions are therefore a measure of the work done, and as it is in electrical communication with the previously mentioned meter, the work is recorded.

The indicator mounted on the near edge of the table is for recording the pressure in the steam chest. Owing to the fluctuating pressure in a locomotive steam chest, it was thought that the inertia of the long column of water in the connecting pipe would make the results worthless. Two indicators were therefore bracketed together with pencils close to each other and in the same horizontal line, so that they both marked on one common drum. One indicator was coupled direct to the steam chest through a connection under 3 inches in length, whilst between the other indicator and the steam chest, 60 feet of bare copper pipe and oil cylinder were interposed. It was found that the one in connection with the long pipe drew a line which was a mean of the pressures shown by the other, and this being suitable, the apparatus was then erected, as shown in the engraving.

The instrument behind the clock is for obtaining the velocity of the wind which blows down a tube kept facing its direction and causes the rise and fall of a pen on the paper drum. The view from the other end (fig. 12) shows this more distinctly, whilst up in the roof a dial can be seen on which the direction of the wind is indicated. Two dials on which the draw-bar pull and speed are shown are provided for the convenience of those persons who may be in the front end.

The external view (fig. 13) shows the measuring wheel previously mentioned. The wind vane, flexible pipes for boiler and steam chest pressures, and the plugs for external electrical connections may be seen at the front end. The spring can be seen, as the side protection plates were taken off for the purpose of the photograph from which our engraving is made. A better idea of the shape is got from the view, figure 14, showing the method of testing it. The special frame, slings, etc., weigh two tons complete, and each weight shown is half a ton, or a total of 15 tons. The weights were screwed up from the floor in pairs, so that the frame remained horizontal; finally, four other half-ton weights were added, bringing the total up to 17 tons. The spring rollers rested on abutments at each end, the top ends being secured by chains for safety, these being left sufficiently slack not to interfere with the free movement of the spring. A curve was plotted giving the ratio between load and deflection, and from this a scale was made.

The general arrangement of the gearing, etc., in connection with the recording apparatus, is shown in figure 15 in more detail than in the photographs. Other auxiliary apparatus, such as pyrometers, draught gauges, etc., are included in the equipment, and indicators of a special type with external springs and pencils controlled by electro-magnets are employed on the front.

For brake tests, a frame supporting three indicators can be fixed on the existing instrument table, and the pressures in the brake cylinder, auxiliary reservoir, and train pipe thus recorded. During locomotive experiments, there will be recorded on the travelling roll of paper the draw-bar pull, work given out, speed, revolutions of driving wheels, steam chest pressure, position of reversing lever, also where indicator cards, smoke-box temperature, and draught readings are taken. The effect that alteration in design has on any of these observations can readily be seen, and comparing the fuel and water consumption with the work given out, the total efficiency due to any change can readily be estimated. During experiments with rolling stock to determine tractive resistance, in addition to recording the draw-bar pull and speed, the velocity and direction of the wind are also noted, so that comparisons can eventually be made with the variables eliminated. Brake tests call for no special comment.

The car is also of use in finding the sighting point of a signal or the distances between two points, an electro-magnetic pen in connection with a push worked by an observer marking the positions on the travelling paper roll. In a similar way, with the aid of the clock beating two seconds, the time lost by speed limitations can also be determined. In fact, any information likely to be of value in connection with locomotives and rolling stock can be obtained with this car.

[621 .134.3]

6. — The work of the Cole superheater.

Figs. 16 to 18, pp. 1280 and 1281.

(*Railroad Gazette.*)

Professor W. F. M. Goss presented a paper before the Indianapolis meeting of the American Society of Mechanical Engineers, giving, in outline, the results of tests of the Cole superheater as applied to the locomotive in the testing laboratory of Purdue University.

For the purpose of observing performance, thermometers reading to 750° Fahr. were inserted in each of the two branch pipes extending between the superheater and cylinders, in the discharge side of all loops, six in number, the length of which varied from the normal, and in the upper loop of the right-hand upper flue, which loop is of normal length. All thermometers were in wells thoroughly jacketed by a current of steam flowing from the stream, the temperature of which was sought.

The results show that the degree of superheat in the steam delivered to cylinders, is largely affected by the rate of evaporation. Thus in figure 16, the average degree of superheate as shown by readings taken from the two branch pipes is plotted against the rate of evaporation. It shows that as the evaporation per square foot of heating surface per hour is increased from 7 to 15 lb., the degree of superheat rises from 122° to 188° Fahr., due doubtless to the fact that the superheating surface, as compared with the direct heating surface, absorbs a greater portion of the total heat as the rate of evaporation increases. For all tests represented upon this diagram, each pound of steam delivered received from the direct heating surface approximately 1,160 B. t. u. and from the superheating surface from 70 to 104 B. t. u. depending upon the rate of power at which the boiler was worked.

Another expression of the fact to which attention has already been called, is well set forth by figure 17, which shows the per cent of the total heat taken up by the water and steam which is absorbed by the superheater, plotted in terms of smoke-box temperature. It will be seen that as the temperature of the smoke-box changes from 600° to 800° Fahr., the heat absorbed by the superheater rises from 5·6 to 8·5 per cent of the total taken up by the water and steam.

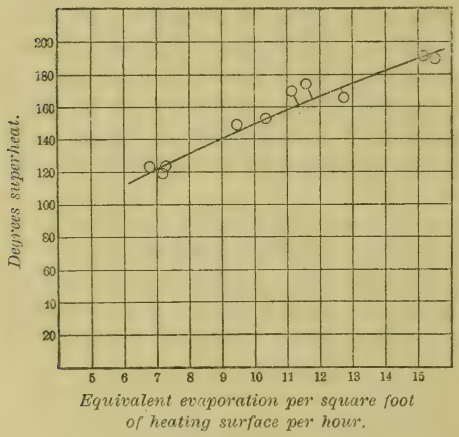


Fig. 16.

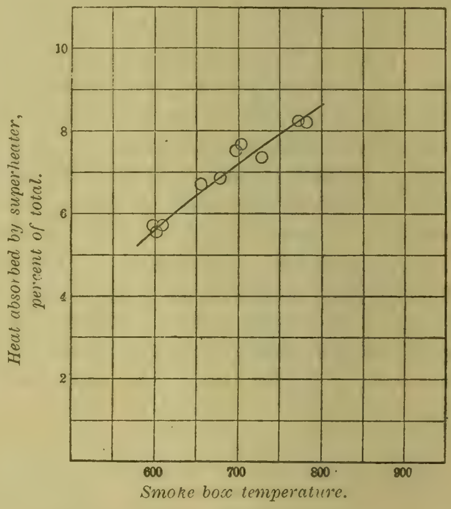


Fig. 17.

The degree of superheating obtained from loops of different lengths is shown graphically by figure 18. It will be seen that the amount of superheating obtained, increases rapidly as the loop is increased in length. This results from the fact that each increment in the length of the loop carries the superheating element nearer the fire-box, and serves to increase the average temperature to which the whole loop is exposed. The effect therefore is two-fold; first, that resulting from an exposure of that surface to a higher average temperature. The basis for these observations (fig. 18) was supplied by the superheating loops arranged in three flues making up a portion of the left-hand vertical row. The lower loops in those flues were, respectively, 80, 92 and 105 inches, while the upper loops were, respectively, 71, 84 and 96 inches. A review of the plotted points at once discloses the fact that a higher degree of superheating is obtained from the lower loop of a given length than is possible from an upper loop of the same or even greater length. Comparing results as obtained, it appears that the lower loop in a given flue, while but a few inches longer than the upper loop, gives from 25 to 30 per cent more superheating effect. This probably is to be accepted as a measure of the advantages which come to that element of the superheating surface which is first to receive the flow of the current of moving gases, though it is not impossible that the lower loop may claim some advantages from its position in the flue.

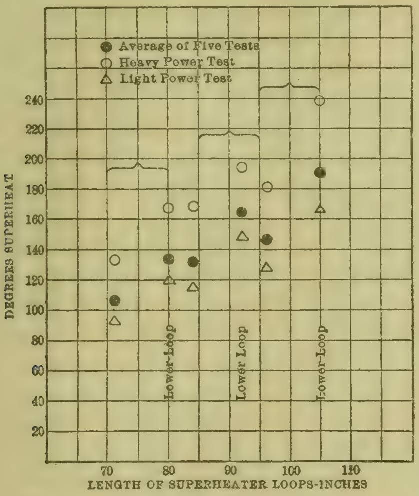


Fig. 18.

It has been observed that the average temperature of the steam in the two branch pipes is always less than the calculated temperature, assuming all superheating loops to give the same performance as those which are under observation. A reason for this must be found in the difference in the volume or quality of the furnace gases transmitted by the several flues.

CYLINDER PERFORMANCE.

While a full analysis of the cylinder performance of the locomotive must be reserved for another time, it is proper here to note that when served with saturated steam (locomotive *Schenectady No. 2*), its performance under normal condition of running was represented by a range of from 24 to 27 lb. of steam per indicated horse-power hour. After being equipped with a superheater, substantially the same locomotive (*Schenectady No. 3*) delivers under ordinary conditions of running an indicated horse-power upon the consumption of from 20 to 22 lb. of superheated steam per hour, a difference of about 17 per cent.

[621 .131.2]

7. — Increase in weight of locomotives.

Figs. 19 to 26, pp. 1283 and 1284.

(*The Railway and Engineering Review.*)

The great increase in weight of locomotives during the past twenty years, is a fact now very frequently referred to in discussing various questions pertaining to railway roadbed, track and structures. Some general data on this increase from one of the prominent locomotive builders of the country, and which can be taken as typical of progress generally in this direction, has, therefore, an important bearing. At the annual meeting of the American Society for Testing Materials, held at Atlantic City in June, Mr. H. V. Wille, of the Baldwin Locomotive Works, contributed a number of diagrams showing increase in weight of locomotives and axle loads from 1885 down to this year. The diagram covers data of the various types of locomotives in largest service during that period, as built at the Baldwin works, locomotives with trailing wheels having been in use only part of that period, not being considered.

Figure 19 shows the average total weight, the average weight on drivers and the average weight per axle for the American or eight-wheel type of locomotive. It is seen that the average total weight has increased from about 69,000 lb. in 1885 to 133,000 lb. in 1905, since when the average weight has undergone a decrease, as this type of locomotive is rapidly going out of use. Figure 20 shows similar data for 10-wheel locomotives, it being noticed that the increase of average weight per axle has been about 100 per cent during the twenty-two years considered. Figure 21 shows the data for mogul locomotives, and figure 22 shows percentages of increase in weight for eight-wheel and mogul locomotives, compared on the same diagram. The parallel progress up to the year 1905 is brought out in a remarkable manner by the diagram.

Figure 23 shows data for consolidation locomotives, and figure 24 percentages of increase for 10-wheel and consolidation locomotives compared on the same diagram. Figure 25 shows increase in maximum axle loads, and figure 26 increase in average weight on each axle. These diagrams will be interesting to engineers in the road department, it being shown that the maximum axle load has increased from about 24,000 lb. in 1885 to about 53,000 lb. in 1907. The increase in average weight on each axle, while very large, has not been quite so striking as the increase in the maximum loads. The diagram shows an advance from about 22,000 lb. in 1885 to 46,000 lb. in 1907.

[621 .138.5]

8. — Hot water boiler washing (1).

(*The Railway and Engineering Review.*)

It seems very generally agreed that washing boilers with cold water is directly responsible for broken staybolts and cracked sheets when the work is crowded, or, in other words, when the cold water is allowed to cool the metal rapidly. At the same time, however, it is believed that when sufficient time is taken to cool the boiler properly, and no sudden changes of temperature are allowed to occur, washing with cold water may be done without ill effects to sheets and staybolts. Demands for power often prompt the roundhouse force to hurry too much when

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(1) Abstract of committee report to Traveling Engineers' Association.

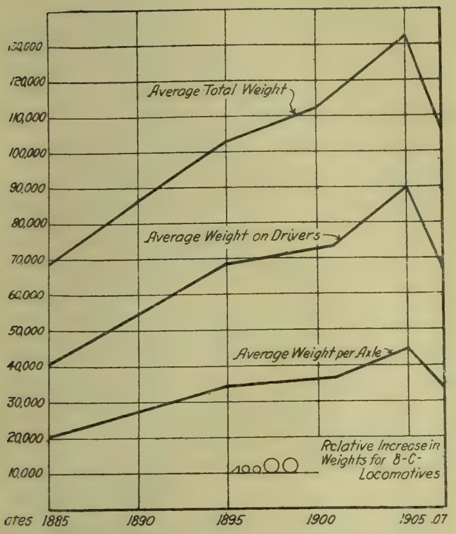

Fig. 19. — Increase in weight of 8-wheel locomotives.

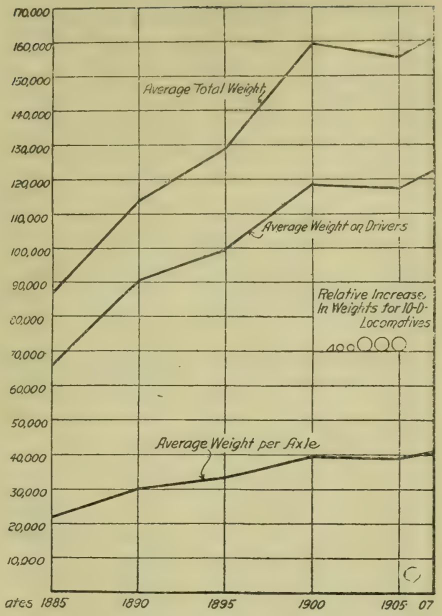

Fig. 20. — Increase in weight of 10-wheel locomotives.

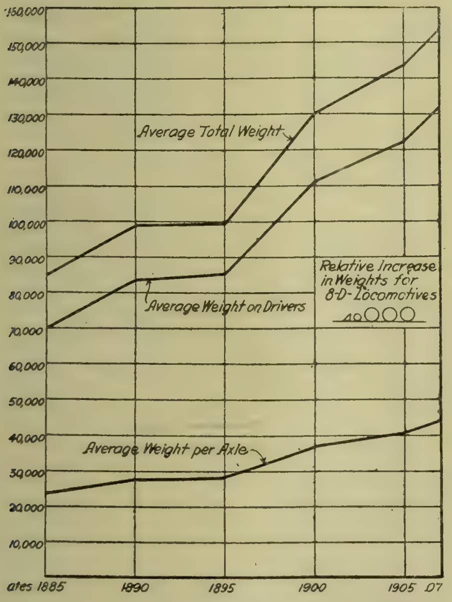

Fig. 21. — Increase in weight of Mogul locomotives.

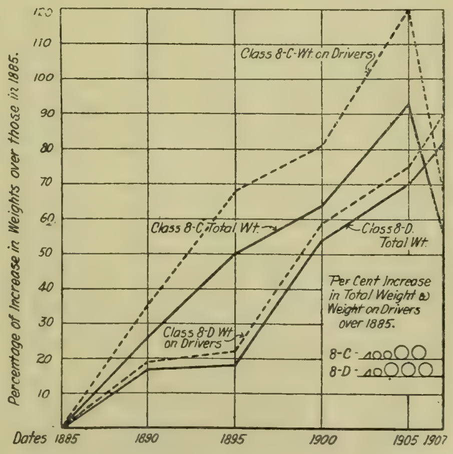

Fig. 22. — Percentages of increase in weight of 8-wheel and Mogul locomotives.

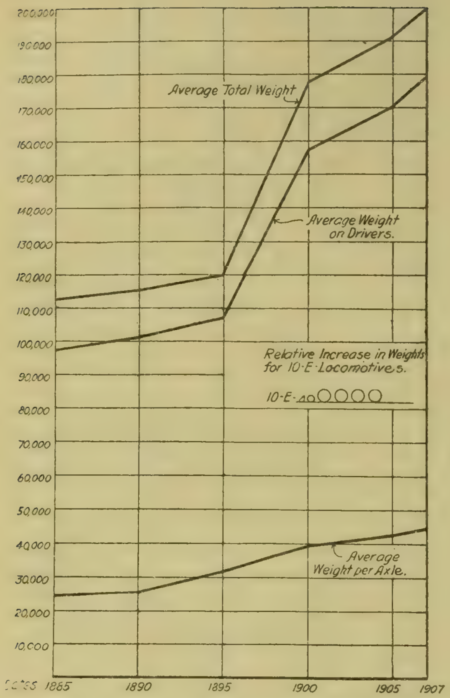

Fig. 23. — Increase in weight of consolidation locomotives.

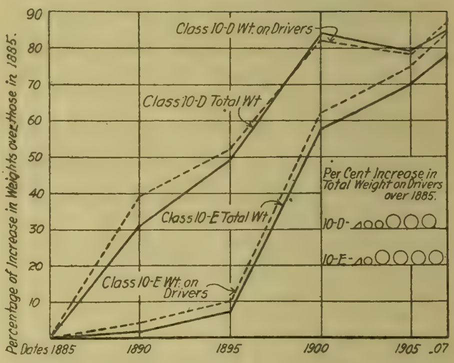

Fig. 24. — Percentages of increase in weights of 10-wheel and consolidation locomomotives.

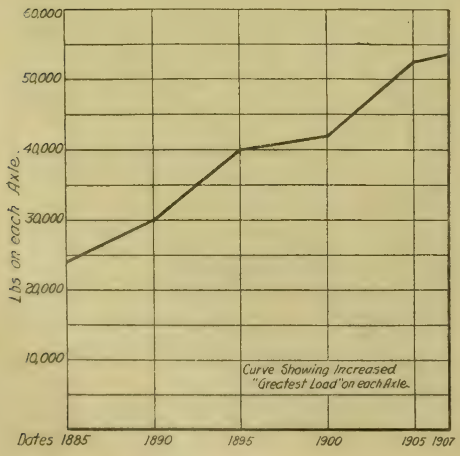

Fig. 25. — Increase in maximum axle loads.

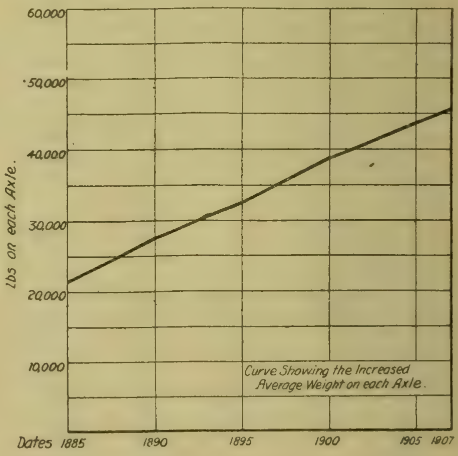

Fig. 26. — Increase in average axle loads.

washing a boiler with cold water, and it is believed that the rapid cooling resulting from such a method is responsible for the cracking of sheets and staybolts.

One road reports that before installing a hot water system for washing out boilers, it was a common occurrence to have staybolts broken after the boilers had been washed out and filled with cold water. This road also had quite a number of cracked side-sheets and the sheets usually cracked while the boiler was being filled with cold water — after the washing-out process had been completed. Since using hot water exclusively for washing and filling boilers, staybolt breakage has been reduced fifty per cent.

A certain road reports that when cold water was used exclusively for washing out and filling boilers, it was necessary to work the tubes over in the fire-box end every time the boiler was washed, in order to prevent engine failures from tubes leaking. With hot water, this is found unnecessary.

The essential features of a system for heating water to be used in washing and filling boilers, which seems to be considered with greatest favor, embodies the principle of utilizing the heat contained in the water discharged for raising the temperature of the water to be used for washing and filling. Utilization of exhaust steam from various sources provides a means of maintaining the temperature of the water when locomotive boilers are not being blown off.

A system operated according to this principle requires a battery of heaters located at some convenient point in or near the roundhouse, where the heat contained in the water and steam blown off may be utilized in heating the water used for washing and filling. The heaters are connected by suitable permanent mains and adjustable connections with the locomotive boiler blow-off cocks in order that all water and steam blown off will be delivered to the heater. The heat so utilized is supplemented by delivering waste steam from the exhaust of stationary engines and air compressors.

The economical feature of this system is that heat which would otherwise be wasted, is utilized to good advantage and the water for washing and filling is heated at an extremely low cost. Where it is necessary to obtain live steam from a boiler to operate the heaters, the economical feature of the system is destroyed.

It has been suggested that in order to wash a maximum number of boilers two pipe lines are necessary between the heaters and the blow-off connections at the boiler. One pipe is for blowing to the cistern and the other is for delivering hot water to the boiler during the process of cooling after the steam has been blown off.

Such an arrangement establishes a pressure in the boiler and discharges water from the boiler more rapidly than the water would naturally escape by gravity alone, because of the frictional resistance offered by the pipes through which it is discharged. It is considered undesirable to blow water and steam from the boiler at the same time, and allow scale and mud to stand on the hot metal without being covered by water. For this reason, it is maintained that water should not be let out of the boiler until the temperature of the metal is the same as the temperature of the water that will be used for washing.

Heating systems may be so arranged that the heat of the steam released when the boiler is blown off, may be used to heat the water for both filling and washing, or the boiler may be washed out with the water originally drawn from the boiler and the filling water alone heated by the steam blown off.

Where the power house of a railway shop plant is equipped with condensing engines, the hot water from the condensers may be led to a pool or cistern and delivered to the roundhouse for washing boilers.

Another method of providing hot water for washing is to deliver all water blown out of the boilers to a receptacle where the water is allowed to settle and the same water is used frequently. Arrangements are necessarily made to dispose of the scale and sludge that settles in the bottom of the receptacle.

A method suggested is to pipe the roundhouse with water and steam connectors at each pit, and provide a portable injector to be carried from one engine to another.

While opinions vary as to the time actually saved by washing and filling boilers with hot water, it is generally considered that an engine will be ready for service in at least one-half of the time usually required when washing and filling with cold water.

The results of some experiments showed that locomotives with a grate surface of 54 square feet could be fired up with about 1,200 lb. of coal when the boiler was filled with hot water, and a good fire was left on the grate. To fire the same engine when the boiler was filled with cold water, required from 2,200 to 2,400 lb. of coal.

At a certain locomotive terminal, where 95 boilers are washed per month the cost of labor and fuel for each boiler washed is as follows :

Seven hours' labor, one man, at 18 cents per hour	$1·26
1,500 lb. coal for building fire, at $2·00 per ton	1·50
200 lb. coal for pumping about 6,000 gallons of water to cool boiler. . .	0·20
Total. . .	$2·96

With a system of hot water washing investigated by those in charge of this terminal, three hours per boiler washed was considered a conservative estimate. The corresponding cost per boiler washed with the hot water system would be :

Three hours' labor, one man, at 18 cents per hour	$0·54
900 lb. coal for building fire, at $2·00 per ton	0·90
Total. . .	$1·44

According to these figures, the saving in labor and fuel for each boiler washing would be $1·52. Washing 95 boilers per month would represent a saving of $144·40 per month, or $1,732·80 per year. Estimating the cost of installing the necessary equipment for a hot water system to be $9,000·00, the figures quoted would represent an interest of 19 per cent on the original investment.

A further economy represented by the hot water system is in the shorter terminal detention. The earning capacity of a locomotive is realized when it is on the road and not when it is in the roundhouse undergoing repairs.

The figures quoted show that an engine may be ready for service in four hours' less time when washed with hot water than when cold water is depended upon. Assuming the average engine mileage to be 10 miles per hour, the time saved would represent 40 engine miles, and at, say, 960 tons per train, the four hours' additional service of each engine would represent 38,400 ton miles. The 95 engines washed per month would then enable the road to obtain 3,648,000 more ton miles per month from engines cared for at the terminal under consideration. In busy seasons, this additional ton mileage would seem representative of considerable economy.

It is generally considered that roundhouse employees can accomplish more and better work when fog and noise of escaping steam are eliminated. Instances sometimes occur where it is almost impossible for a workman to see a few feet in front of him and such conditions are certainly not conducive to efficient work. When the wash-out section is filled with steam and fog, it is impossible for men to move around rapidly, especially so with trucking, and there is always danger of men stumbling over obstacles on the floor, falling into pits or colliding with some one carrying a heavy tool or piece of work. Piping the blow-off water and steam provides an opportunity for men to work in the pit beneath the engine and it is necessary to wait until a boiler is blown off before machinists' work can be begun.

The number of boilers which should be washed per day to justify installing a hot water washing system, would then seem to depend on the peculiar local governing conditions and the interest that would be represented by the investment. On the other hand, elaborateness of the plant might well vary with the amount of work to be done. For instance, if but very little boiler washing is done at a roundhouse, the use of a portable injector would seem practical, for it is more than likely that there is a boiler in the roundhouse for operating the washout pump, even if there are but five or six stalls in the house.

The results obtained by the hot water system of washing and filling boilers, indicate that not only is much time saved in turning engines at terminals, but repairs to boilers in engine house and back shop are reduced by this method of caring for boilers. In bad water districts, the use of treated water in connection with the hot water system of washing and filling, results very successfully in lengthening the life of tubes and fire-boxes.

A representative from a western road advises that before the installation of a hot water system in 1903, tubes were removed from freight engines every 10,000 miles and from passenger engines after 15,000 miles' service. Since this system has been in operation, the mileage of the tubes has been doubled.

A representative of a road that has had a hot water system in operation for fifteen months, advises that engine failures due to leaking tubes and side-sheets have decreased 50 per cent and that repairs for boiler work have decreased 22 per cent.

Another representative says that before three hot water plants were put in operation on a division, the heavy power in freight service made 30,000 miles between flue settings. The same power is now making 50,000 to 60,000 miles, using the same feed water as formerly.

The locomotive terminals having in operation hot water system of washing and filling boilers that seem worthy of investigation are on the A., T. & S. F. Ry., at Albuquerque and Raton, N. M.; C. & O. Ry., at Clifton Forge, Va., Hinton, W. Va., and Russell, Ky.; C. B. & Q. Ry., at Grand Crossing, Wis.; C. I. & S. Ry., at Gibson, Ind.; C. L. S. & R. Ry., at South Chicago, Ill.; C. M. & St. P. Ry., at Milwaukee, Wis.; C. R. I. & P. Ry., at Eldon, Ia., Blue Island and 47th St., Chicago, Ill.; C. C. C. & St. L. Ry., at Lyons and Mt. Carmel, Ill.; I. C. R. R., at East St. Louis, Ill.; L. S. & M. S. Ry., at Elkhart, Ind., Toledo, Ashtabula and Collinwood, O.; N. Y. C. & H. R. R. R., at Albany, N. Y.; N. Y., N. H. & H. Ry., at South Boston, Mass.; P. & L. R. R. R., at McKees Rocks, Pa.; S. P. Ry., at Oakland, Cal., and Wabash R. R., at Montpelier, O., Fort Wayne and Peru, Ind.

[385. (09.2]

OBITUARY

Harry SMART,

Ex-secretary of the Railway Clearing House,
Delegate to the sixth session of the Railway Congress (Paris, 1900)
and reporter to the seventh session (Washington, 1905).

We are exceedingly sorry to have to report the loss of Mr. Harry Smart who prepared the very interesting report for the last session of the Congress in Question XIII : *Slow freight rates.*

We reproduce below the paragraph which the *Railway News* devoted to the memory of our highly esteemed collaborator and we join most heartity in the regret expressed by that journal :

It is with much regret we have to announce the death of Mr. Harry Smart, late secretary of the Railway Clearing House, which event took place at his residence at Twickenham Park on Sunday October 20, 1907. Mr. Smart had been seriously ill for some few months past, and at the end of last month resigned his post in consequence. It was sincerely hoped by his many friends that relief from the arduous duties attaching to such a responsible position as chief officer of so important an establishment would have a beneficial effect upon his health, but it was otherwise decreed, and he gradually became worse, and finally passed away painlessly and unconsciously. Mr. Smart, who entered the service in 1860, and was promoted to the secretaryship in 1890 upon the death of Mr. Dawson, has left a name behind him which will long be remembered in the Clearing House, for he worked strenuously for the welfare of the large staff under him, and took great personal interest in the various funds, clubs, and societies promoted by the staff, which he did much to improve and place upon sound bases. He had many friends throughout the railway world, including some outside the United Kingdom, and the superintendents and goods managers who have been holding their usual quarterly meetings at the Clearing House this week have shown their appreciation of him by passing special resolutions expressing regret at the loss of his valuable assitsance and their condolence with his family.

The Committee of Management.

NEW BOOKS AND PUBLICATIONS

[**621** .33 & 385. (04]

CAMPIGLIO (A.), Engineer, President of the Italian Union of Local Railways and Tramways. — **La trazione elettrica sulle ferrovie (Electric traction on railways)**. — Pamphlet, large 16^{mo} (24 × 17 centimetres [$9\,{}^{7}/_{16} \times 6\,{}^{11}/_{16}$ inches]), 30 pages. — 1907, Milan, Stab. Tipo-Litografico L. Zanaboni e Gabuzzi di Luigi Gabuzzi, Via Pontana, 12 (Porta Vittoria).

Mr. Campiglio, Engineer, President of the Italian Union of Local Railways and Tramways, has just published a note on electric traction by monophase current, as applied to trunk lines.

He first makes an estimate of the cost of electric traction on trunk lines, as compared with steam traction. As starting-point he gives a table containing the figures which he has previously established; from them it appears that steam traction is more economic than electric traction by continuous current and third rail, the difference becoming reduced as the number of trains running in both directions increases, so that when there are twenty pairs of trains it only amounts to 11 centimes per train-kilometre (1·699*d.* per train-mile), all the factors involved being taken into consideration, including interest and amortization of capital outlay.

If however the continuous current, instead of being supplied by a central station using steam, is obtained from water-power, the difference in favour of steam, again in the case of twenty pairs of trains, falls to 1 centime per train-kilometre (0·154*d.* per train-mile).

Taking next the case of monophase current transmitted at high pressure, Mr. Campiglio finds that with a small number of trains the advantages of electric traction are small or nil. But when there is a service of twenty trains in each direction, electric traction by monophase current is more economic. The saving per train-kilometre amounts to :

Central station using steam.

Transmission by 2 wires	0 centime.
— by 1 wire	2 centimes (0·309 penny per train-mile).

Water-power.

Transmission by 2 wires	10 centimes (1·545 penny per train-mile).
— by 1 wire	13 — (2·008 pence —).

The author then more or less succinctly considers the application of this system of traction, in order to show that it is favoured in all countries, and concludes that those where much water-power is available will soon adopt it.

Will this however soon be so in Italy?

Mr. Campiglio regrets that he is unable to answer this question in the affirmative, and gives his reasons :

" In a short time we shall see in Italy, as I have already stated, new applications of electric traction on the Giovi line, on the Porretta line, on the Milan-Lecco line; and we would certainly also see others on the railways operated by private enterprise, if the conditions of repurchase by the State specified in the concessions, were not against it, for it is very clear that no company is likely to incur large expenditure on installations, when the State has the power, either immediately or in a very short time, to repurchase on the basis of the average receipts of the quinquennial period immediately before the repurchase; for it is certain that not even increased receipts would compensate for the expenditure incurred. "

Similar reasons might be given for the delay that will occur everywhere in the electrification of the trunk lines; it is, in short, the doubling of the lines, or more generally, of the original capital outlay.

E. G.

[385. (09.3 (.45) & 385. (04]

SPERA (Giuseppe), engineer. — **L'Esercizio ferroviario in Italia nei suoi rapporti con l'economia del paese e la Scienza dei Trasporti (Railway operation in Italy and its connection with the general economics of the country and the science of transport).** — One volume, octavo (23 × 15 centimetres [9 × 6 inches]), 166 pages. — 1907, Rome, Cooperative Press.

Mr. Spera has already published three large volumes on Italian railway questions (1) and they have earned him no mean reputation. The Milan Engineering School invited him to express his ideas and expound his theory before its members, and this he did amidst the applause of his audience at a meeting held on June 20, 1907.

Mr. Spera has recently published his lecture of which we shall give the substance, for though we do not share all his views, we think it expedient that they should be made known.

Mr. Spera begins by stating that the operation of the railways by the State is an accomplished fact, and that now everybody has faith in its success, a faith that seemed lost during the first few months.

He then begins to consider the railway operation that he regards as least suited to the needs of the country — one founded on empiricism built up of hopeless prejudices and mistakes. The mere fact that a milliard of francs (£40 millions) has just been voted to put the railways in proper condition, demonstrates the want of care that had been shown of late years. But, according to Mr. Spera, it is not only the lack of proper means (double track, stations, rolling stock) but the defects in the method of operation that is to be deplored.

The traffic, that is to say, the conveyance of passengers and goods, possesses on the one hand, general characteristics common to all countries but on the other, it assumes special features according to the economic and topographical conditions of each country and in accordance with its wealth, its manufactures, and the development of its agriculture.

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(1) Vide *Bulletin of the Railway Congress,* June 1899, p. 877, and November 1905, p. 2358.

In Italy, the traffic falls into three categories :

Long distance traffic, from north to south ;

Medium distance traffic, between the great cities ;

Short distance traffic, between adjacent territories and round the great cities.

This last class of traffic is completely neglected. And yet it deserves special attention, because passengers travelling under 100 kilometres (62 miles) represent by themselves four fifths of the receipts and in the case of goods 53 per cent. This traffic is entrusted to mixed or omnibus trains in which are carried both passengers and goods as a rule, though their requirements are too different to be met by the same methods.

" It may be asserted ", states Mr. Spera, " without exaggeration that our operation in no " way corresponds with the needs of our traffic, and this is proved by comparing the " results obtained with those of other countries. "

For, on the Italian railway system amounting to 12,000 kilometres (7,450 miles), 19 million tons are carried; in France, 141 million, or more than double; in Germany, 280 million on 42,000 kilometres (26,100 miles). As regards passengers, except for Russia where there is less than one journey per inhabitant, every other country far exceeds Italy where the estimate is below two journeys (1·82) for each inhabitant, as against 27 in England, 20 in Switzerland, 17 in Prussia and 9 in France.

Mr. Spera next sketches the bases of a method of railway operation that he would regard as reasonable.

In the first place, absolute separation between the passenger and goods services.

Secondly : subdivision of lines into sections; service of long and medium distance passengers to be carried on by through trains stopping only at the main stations of sections ; on each section local trains, as light as on tramways, would run and to these is entrusted the service of short distance passengers. Each through train should be preceded and followed by a local train which brings together and distributes the passengers that the through train has brought to the principal station of the section.

As regards goods, Mr. Spera suggests the abolition of the slow traffic, which is so slow that it hardly exceeds that on ordinary roads with animal traction. He next proposes that the Management should itself undertake to deliver goods. Finally, he would desire to find some way of interesting station masters in the development of traffic.

Mr. Spera next deals with what he calls the *mechanism*, namely the *track*, the *station*, the *vehicle*. He wants a track better laid and capable of carrying heavy traffic; large, heavy, comfortable passenger cars; capacious goods trucks like the American ones.

Mr. Spera suggests separate stations for passengers and goods. The latter ought to be kind of *land wharf*, and they ought to be equipped like a harbour to facilitate the rapid handling of goods.

Naturally on secondary lines, track, stations and vehicles ought to be suited to the class of traffic that has to be accommodated.

Mr. Spera goes on to calculate what would have to be spent to put the Italian railways in good condition to repay expenditure. He remarks that the capital expended on railways returns 4·40 per cent in Belgium, 3·50 in Russia, in France and in Hungary, 3 per cent in Denmark and in Roumania, and only 1·70 per cent in Italy. He quotes the example of Prussia which after having poured out millions on its railways, has succeeded in raising its profits from 4 to 7 per cent. And according to his estimates, the same results could be attained in Italy.

Mr. Spera closed his lecture by summarizing his views, and in conclusion, said that it was necessary to fight against empiricism, prejudice, the mistakes that ruined railway operation in Italy, and substitute therefor scientific thought which knew how to interpret the needs of traffic and adapt thereto appropriate machinery.

" In a word ", said he, " what my brain is inspired with is the audacious idea of trying " to build up a science of transport, which may open to the scientific world a vast and " unexplored horizon. "

We for our part feel bound to make some reservations with regard to the views expounded by Mr. Spera, though we acknowledge his profound scholarship in the subject.

R.

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016 .385. (02]

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(November, 1907.)

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CHABOT (de).

Les automobiles et leurs moteurs.

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907 **62**. (02

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Quelques applications de l'électrotechnie dans l'Europe centrale. I : Chemins de fer électriques et tramways. II : Ateliers de constructions électriques. III : Transports d'énergie.

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Mécanique, électricité et construction appliquées aux appa-eils de levage. — Les ponts roulants actuels.
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The art of railroading, or the technique of modern transportation.

Chicago, Ill., Railway Publications Society. 7 volumes, 3,230 pages, profusely illustrated. (Price : $30.)

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Electrical traction. Vol. I : Direct current. Vol. II : Alternating current.

London, Edward Arnold. 2 volumes (8 $^3/_4$ × 5 $^3/_4$ × 1 $^1/_4$ inches and 8 $^3/_4$ × 5 $^3/_4$ × 1 $^1/_2$ inches), 475 and 328 pages, many ill. and diagrams. (Price : 15*s*. each volume.)

In Spanish.

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CLARO (D. Arsenio), Ayudante de obras públicas.

Tablas para el trazado de curvas.

Un volumen en 4° y encuadernado en tela. (Precio 5.50 pesetas.)

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MINISTERIO DA INDUSTRIA, VIAÇÃO E OBRAS PUBLICAS.

Relatorio apresentado ao presidente da Republica dos Estados Unidos do Brazil pelo Ministro do Estado da industria, viação e obras publicas Miguel Calmon du Pin e Almeida. No anno de 1907.

Rio de Janeiro, imprensa nacional. In-8°, (240 × 160), Vol. I, 8 + xxx + 622 pags; Vol. II, 6 + 623-1,105 pags.

[016 .385. (05]

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Bulletin des accidents d'appareils à vapeur survenus ndant l'année 1905. (Résumé résultant de l'étude des ssiers administratifs.) (3 tableaux.)

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1907 **385**. (07.2 & **621** .131.3

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1907 **625** .2 (06 & **625** .216

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Essais d'attelages des « Master Car Builders ». (6,200 mots & fig.)

1907 **625** .245

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Nouveau wagon pour l'étude du frein à air comprimé du « Chicago, Burlington & Quincy Railway ». (1,200 mots & fig.)

1907 **621** .132.3

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Locomotives compound à quatre cylindres des chemins de fer de l'État italien. (1,850 mots & fig.)

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Locomotive compound pour le chemin de fer du Saint-Gothard. (850 mots & fig.)

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Chariot à bagages électrique. (550 mots & fig.)

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La nouvelle gare de triage de Mannheim. (1,450 mots fig.)

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Bibliographie mensuelle des chemins de fer. — Livres. fiches.)

1907 **016** .385. (05
illetin du Congrès des chemins de fer, nº 10, octobre, p. 131.

Bibliographie mensuelle des chemins de fer. — Périoques. (132 fiches.)

Bulletin des transports internationaux par chemins de fer. (Berne.)

1907 **656** .24
ill. des transports intern. par ch. de fer, nº 10, octobre, p. 354.

De la recevabilité des actions en rectification de taxes ntre les chemins de fer ayant concouru au transport rt. 12 et 27 de la C. I.) (4,000 mots.)

Éclairage électrique. (Paris.)

1907 **621** .333
lairage électrique, nº 40, 5 octobre, p. 5.

BERTHENOD (J.). — Sur l'emploi des batteriesmpon pour la traction par moteurs à explosion. ,500 mots & fig.)

Génie civil. (Paris.)

1907 **625** .13
Génie civil, nº 1321, 5 octobre, p. 374.

Les travaux du tunnel de Gattico (Lombardie). (2,800 mots & fig.)

1907 **621** .87
Génie civil, nº 1322, 12 octobre, p. 385.

Grue de 150 tonnes des chantiers navals John Brown à Clydebank (Angleterre). (2,700 mots & fig.)

1907 **62**. (01 & **624**. (01
Génie civil, nº 1322, 12 octobre, p. 391.

CAUFOURIER (P.). — Stabilité des voûtelettes constituant le platelage des ponts métalliques. (2,300 mots & fig.)

1907 **621** .14
Génie civil, nº 1323, 19 octobre, p. 401.

LE VERGNIER (A.). — Fiacre automobile à transmission par plateaux de friction. (1,200 mots & fig.)

1907 **621** .331 & **621** .388. (01
Génie civil, nº 1324, 26 octobre, p. 431.

L'efficacité des paratonnerres pour cheminées d'usines. (1,200 mots & fig.)

Revue générale des chemins de fer et des tramways. (Paris.)

1907 **624**. (01
Revue générale des chemins de fer, nº 4, octobre, p. 321.

PENTECOTE (E.). — Ponts de chemins de fer à une travée et à voie normale. (3,300 mots & fig.)

1907 **625** .4
Revue générale des chemins de fer, nº 4, octobre, p. 335.

LE CHATELIER (J.). — Le métropolitain à marchandises de Chicago. (3,500 mots, 1 tableau & fig.)

1907 **385** .113 (.42)
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Résumé du rapport du « Board of Trade » sur la longueur, la situation financière et les résultats généraux de l'exploitation des chemins de fer du Royaume-Uni, pour l'année 1905. (Tableaux.)

1907 **385** .58
Revue générale des chemins de fer, nº 4, octobre, p. 355.

Le contrôle du travail des agents de chemins de fer en 1905. (6,000 mots & 3 tableaux).

907 **656** .235 (.47)
vue générale des chemins de fer, nº 4, octobre, p. 366.

Nouveau tarif intérieur russe pour le transport des rchandises. (1,600 mots & tableaux.)

907 **385**. (09.1 (.65)
vue générale des chemins de fer, nº 4, octobre, p. 372.

Le développement du réseau algérien. (1,300 mots fig.)

907 **621** .132.3
vue générale des chemins de fer, nº 4, octobre, p. 374.

Locomotives Pacific de la compagnie d'Orléans. (500 ts & fig.)

1907 **625** .144.4
vue générale des chemins de fer, nº 4, octobre, p. 376.

Thermomètre spécial pour la pose des rails. (500 mots fig.)

In German.

Annalen für Gewerbe und Bauwesen. (Berlin.)

1907 **621** .132.8
nalen für Gewerbe und Bauwesen, Nr 727, 1. Oktober, S. 138.

Motorwagen oder Lokomotive. (5 200 Wörter.)

1907 **621** .97
nalen für Gewerbe und Bauwesen, Nr 728, 15. Oktober, S. 153.

PETER. — Neuerungen im Bau dampfhydraulischer hmiedepressen. (1 700 Wörter & Abb.)

1907 **621** .138.2
nalen für Gewerbe und Bauwesen, Nr 728, 15. Oktober, S. 157.

ZIMMERMANN (F.). — Schlackenaufzug. (1 000 örter & Abb.)

Beton und Eisen. (Berlin.)

1907 **624** .2 (01
ton und Eisen, Heft X, Oktober, S. 252.

Eisenbetonträger für grosse Spannweiten, System erendeel. (1 400 Wörter & Abb.)

Bulletin des Internationalen Eisenbahn-Kongress-Verbandes. (Brüssel.)

1907 **656** .212
lletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 955.

NORTH (H. M.). — Theorie des Entwerfens von ossen Güterbahnhöfen. (11 900 Wörter, 1 Tabelle Abb.)

1907 **621** .33
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 984.

MÜHLMANN. — Elektrischer Betrieb auf Vollbahnstrecken mit starken Steigungen. (3 500 Wörter & Abb.)

1907 **625** .175
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 994.

HONEMANN (A.). — Gleisfahrrad. (1 450 Wörter & Abb.)

1907 **656** .212
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1000.

FRAHM. — Der neue Verschiebebahnhof bei Wath in England. (900 Wörter & Abb.)

1907 **656** .253
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1003.

Ein neues auf der Lokomotive befindliches Wiederholungssignal. (3 000 Wörter & Abb.)

1907 **656** .256.3
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1016.

Ein neues Blocksignal-System bei der Pennsylvania-Bahn. (1 600 Wörter & Abb.)

1907 **385** .113 (.4)
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1022.

COLSON (C.). — Die Eisenbahnen in den Jahren 1905-1906. (Betrachtungen über Transportfragen.) (7 000 Wörter & 2 Tabellen.)

1907 **385**. (01 (.57)
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1038.

SAMMONS (T.). — Transsibirischer Eisenbahnverkehr. (2 550 Wörter.)

1907 **621** .132.5
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1042.

Verbund Lokomotive der St. Gotthard-Bahn. (1 050 Wörter & Abb.)

1907 **625** .245
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1046.

Ein neuer Wagen für Lehrzwecke über Luftdruck-Bremsen : Chikago, Burlington & Quincy-Bahn. (1 050 Wörter & Abb.)

1907 **625** .232
Bulletin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1052.

Der erste aus Stahl gebaute Pullman-Schlafwagen. (1 050 Wörter & Abb.)

907 **625** .216
letin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1055.
Selbsttätige Eisenbahn-Kuppelungen. (1 350 Wörter
Abb.)

907 **625** .216
letin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1061.
Die Gouldische Reibungs-Kuppelung. (550 Wörter
Abb.)

907 **625** .252
letin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 1063.
Der « Armbrust »-Bremsschuh. (650 Wörter & Abb.)

907 **016** .385. (02
letin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 129.
Monatliches Verzeichnis der Eisenbahnliteratur. —
cher. (8 Zettel.)

907 **016** .385. (05
letin des Eisenbahn-Kongresses, Nr 10, Oktober, S. 131.
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tschriften. (132 Zettel.)

ektrische Kraftbetriebe u. Bahnen. (München.)

907 **621** .335
ktr. Kraftbetriebe u. Bahnen, Heft 29, 14. Oktober, S. 561.
— — — Heft 30, 24. — S. 585.
SCHROEDTER (O.). — Eine elektrische Lokomotiv-
derung für 2 000 Volt Gleichstrom. (4 400 Wörter
Abb.)

907 **625** .154
ktr. Kraftbetriebe u. Bahnen, Heft 30, 24. Oktober, S. 594.
Elektrisch betriebene Drehscheiben. (550 Wörter
Abb.)

rgan für die Fortschritte des Eisenbahnwesens in technischer Beziehung. (Wiesbaden.)

907 **621** .132.3
gan für die Fortschritte des Eisenbahnw., 11. Heft, S. 219.
LAKE (C. S.). — Die neuen Lokomotiven der englischen
estbahn. (1 100 Wörter, 2 Tabellen & Abb.)

907 **725** .33
gan für die Fortschritte des Eisenbahnw., 11. Heft, S. 222.
CAUER (W.). — Die Gestalt der Lokomotivschuppen.
400 Wörter.)

907 **625** .26
gan für die Fortschritte des Eisenbahnw., 11. Heft, S. 224.
ZIMMERMANN (F.). — Werkstätte zur Untersuchung
vision) der Wagen in der Hauptwerkstätte Karlsruhe.
0 Wörter.)

1907 **625** .3
Organ für die Fortschritte des Eisenbahnw., 11. Heft, S. 225.

STROHMEYER. — Die Albula-Bahn. (2 000 Wörter & Abb.)

1907 **625** .143.5
Organ für die Fortschritte des Eisenbahnw., 11. Heft, S. 232.

Haftkraft der Hakennägel und Schwellenschrauben in den Schwellen. (350 Wörter, 6 Tabellen & Abb.)

1907 **621** .132.1
Organ für die Fortschritte des Eisenbahnw., 11. Heft, S. 234.

Bezeichnung der Lokomotiv-Achsanordnungen. (250 Wörter & 1 Tabelle.)

1907 **621** .33 & **625** .4
Organ für die Fortschritte des Eisenbahnw., 11. Heft, S. 236.

Die Pariser Stadtbahn. (1 200 Wörter.)

Schweizerische Bauzeitung. (Zürich.)

1907 **625** .255
Schweizerische Bauzeitung, Nr 17, 26. Oktober, S. 217.

KUMMER (W.). — Die Verfahren der elektrischen Bremsung von Seriemotoren für Gleichstrom und Wechselstrom bei elektrischen Bahnen und besonders bei elektrischen Bergbahnen. (2 500 Wörter & Abb.)

Zeitschrift für Architektur und Ingenieurwesen. (Wiesbaden.)

1907 **624** .6 (01
Zeitschrift für Architektur und Ingenieurw., Heft 5, S. 403.

ENGESSER (F.). — Ueber weitgespannte Wölbbrücken. (12 600 Wörter, 1 Tabelle & Abb.)

1907 **625** .12 (01
Zeitschrift für Architektur und Ingenieurw., Heft 5, S. 441.

MOHR (O.). — Eine neue Theorie des Erddrucks. (3 500 Wörter & Abb.)

Zeitschrift des österreichischen Ingenieur- und Architekten-Vereines. (Wien.)

1907 **621** .135. (01
Zeit. des öst. Ingen.- und Archit.-Ver., Nr 41, 11. Oktober, S. 712.
— — — — Nr 42, 18. — S. 725.

KUTSCHERA (A.). — Ueber die Bestimmung der Achsbelastungen bei Lokomotiven. (6 500 Wörter & Abb.)

1907 **625** .143.4
Zeit. des öst. Ingen.- und Archit.-Ver., Nr 42, 18. Oktober, S. 734.

EDELSTEIN (L.). — Mittel zur Beseitigung des Spielraumes zwischen Schiene und Lasche. (1 500 Wörter & Abb.)

Zeitschrift für Kleinbahnen. (Berlin.)

1907 **313** : **625** .61 (.493)
eitschrift für Kleinbahnen, Heft 10, Oktober, S. 815.

Die Kleinbahnen in Belgien im Jahre 1906. (Tabellen.)

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eitschrift des Vereines deutscher Ingenieure. (Berlin.)

1907 **621** .132.8
eit. des Vereines deutsch. Ingen., Nr 42, 19. Oktober, S. 1645.

DOEPPNER (A.). — Dampftriebwagen zur Postbeirderung auf den Italienischen Staatsbahnen. (900 Wörter Abb.)

1907 **624** .2 (01
eit. des Vereines deutsch. Ingen., Nr 42, 19. Oktober, S. 1661.

VIANELLO (L.). — Der Flachträger. (4 000 Wörter Abb.)

1907 **621** .131.1
eit. des Vereines deutsch. Ingen., Nr 43, 26. Oktober, S. 1695.

SANZIN (R.) — Untersuchung der Widerstände einer 3-gekuppelten Lokomotive. (2 500 Wörter, 4 Tabellen Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1907 **656** .234 (.73)
itung des Vereins, Nr 76, 2. Oktober, S. 1151.

Der 2 Cents-Eisenbahnfahrpreis. (1 500 Wörter.)

1907 **656** .253
itung des Vereins, Nr 79, 12. Oktober, S. 1197.

FRAHM. — Das Vorsignal auf den englischen Eisenihnen. (3 000 Wörter & Abb.)

1907 **621** .33
itung des Vereins, Nr 80, 16. Oktober, S. 1213.
— — Nr 81, 19. — S. 1229.

GIESLER (A.). — Der Akkumulatorwagenbetrieb der fälzischen Eisenbahnen. (4 500 Wörter, 5 Tabellen & bb.)

1907 **656** .235
itung des Vereins, Nr 83, 26. Oktober, S. 1261.

Ueber die Tarifierung von Holz und Holzwaren. 100 Wörter)

1907 **385** .61
itung des Vereins, Nr 84, 30. Oktober, S. 1281.

Die Ergebnisse der dritten « internationalen Konfenz für die technische Einheit im Eisenbahnwesen » Bern im Mai 1907. (2 100 Wörter.) (S. *Bulletin des ternationalen Eisenbahn-Kongress Verbandes*, Nr 8, igust 1907.)

In English.

American Engineer and Railroad Journal. (New York)

1907 **385**. (07.1
American Engineer & R. Journal, No. 10, October, p. 373.

A rational apprentice system. (8,500 words & fig.)

1907 **621** .132.8
American Engineer & R. Journal, No. 10, October, p. 391.

Steam motor car. (1,000 words & fig.)

1907 **625** .235
American Engineer & R. Journal, No. 10, October, p. 401.

All-steel passenger cars. (1,600 words & fig.)

Bulletin of the International Railway Congress Association. (Brussels.)

1907 **656** .251
Bulletin of the Railway Congress, No. 10, October, p. 971.

WEISSENBRUCH (L.) & KIRSCH (L.). — Note on the new iron posts used by the Belgian State Railway for wire transmissions for operating signals. (850 words & fig.)

1907 **621** .133.7
Bulletin of the Railway Congress, No. 10, October, p. 976.

GÖLSDORF. — Apparatus for preventing the formation of coherent scale in boilers. (550 words & fig.)

1907 **625** .233. (01
Bulletin of the Railway Congress, No. 10, October, p. 980.

HUELS (F. W.). — Vibrations in passenger trains from high speed electric lighting engines. (Paper and discussion.) (7,900 words, 4 tables & fig.)

1907 **625** .253
Bulletin of the Railway Congress, No. 10, October, p. 1005.

PARKE (F. H.) & DUDLEY (S. W.). — Recent developments in air brake control apparatus. (7,400 words & fig.)

1907 **625** .245
Bulletin of the Railway Congress, No. 10, October, p. 1025.

EMERY, Jr (A. H.). — A new railway car dynamometer. (7,500 words & fig.)

1907 **625** .216
Bulletin of the Railway Congress, No. 10, October, p. 1044.

Automatic railway couplings. (1,200 words & fig.)

907 **621** .33 (.42)
lletin of the Railway Congress, No. 10, October, p. 1050.

Applications of electricity on English railways. (800 rds & 4 tables.)

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907 **621** .132.3
lletin of the Railway Congress, No. 10, October, p. 1053.

KING (CHARLES R.). — Italian Prairie balanced-mpound locomotives, and their future. (2,300 words fig.)

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907 **625** .232
lletin of the Railway Congress, No. 10, October, p. 1059.

Invalid and family compartment cars for the London North Western. (900 words & fig.)

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907 **625** .236 & **625** .2 (06
lletin of the Railway Congress, No. 10, October, p. 1063.

Up-to-date cleaning of passenger equipment. (1,450 rds.)

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907 **621** .132.1 (.73)
lletin of the Railway Congress, No. 10, October, p. 1066.

A tabular comparison of notable examples of recent comotives. (4 tables.)

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907 **313** . **385** (.42)
lletin of the Railway Congress, No. 10,October, p. 1074.

The chief English railways in 1906. (700 words & tables.)

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907 **313** .385. (01
lletin of the Railway Congress, No. 10, October, p. 1077.

Classifications for mileage statistics and road and uipment expenditures. (3,300 words.)

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907 **016** .385. (02
lletin of the Railway Congress, No. 10, October, p. 129.

Monthly bibliography of railways. — Books. (8 labels.)

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907 **016** .385. (05
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Monthly bibliography of railways. — Periodicals. 32 labels.)

Engineer. (London.)

907 **625** .245
gineer, No. 2701, October 4, p. 334.

North-Eastern Railway dynamometer car. (1,200 ords & fig.)

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907 **385** .581 (.42)
gineer, No. 2701, October 4, p. 343.

Labour on railways. (1,300 words.)

1907 **625** .1 (.42)
Engineer, No. 2702, October 11, p. 361.

New route between Bristol and Birmingham. (2,800 words & fig.)

1907 **621** .133.1 (01
Engineer, No. 2703, October 18, p. 382.

JACOBSEN (A.). — Locomotive coals. (3,000 words, 4 tables & fig.)

1907 **656** .281
Engineer, No. 2703, October 18, p. 386.

The Shrewsbury accident. (700 words & fig.)

1907 **385**. (06.111
Engineer, No. 2703, October 18, p. 387.

International railway congress. (900 words.) (S. *Bulletin of the Railway Congress*, No. 5, May 1907.)

1907 **656** .281
Engineer, No. 2703, October 18, p. 393.

The Shrewsbury Railway accident. (1,200 words.)

1907 **625** .143.3
Engineer, No. 2703, October 18, p. 401.

Rail corrugation. (3,000 words & fig.)

1907 **621** .134.3
Engineer, No. 2704, October 25, p. 407.

GARBE (R.). — The application of highly superheated steam to locomotives. (3,200 words & fig.)

Engineering. (London.)

1907 **621** .132.3
Engineering, No. 2180, October 11, p. 486.

Express locomotive for the Prussian State Railways. (1,500 words & fig.)

1907 **624** .52
Engineering, No. 2181, October 18, p. 510.

SKINNER (F. W.). — The Quebec bridge. (3,400 words.)

1907 **656** .281
Engineering, No. 2181, October 18, p. 530.

Shrewsbury railway accident. (1,100 words & fig.)

1907 **621** .331
Engineering, No. 2181, October 18, p. 535.

Long Island City power-station of the Pennsylvania Railroad Company. (4,000 words & fig.)

1907 **625** .254
gineering, No. 2182, October 25, p. 563.

The Vacuum brake and slack brake gear. (1,400 rds, 2 tables & fig.)

1907 **669** .1
gineering, No. 2182, October 25, p. 575.

DEMOZAY (L.). — The hardening of steel (1,000 rds, 2 tables & fig.)

Engineering Magazine. (London.)

1907 **669** .1 (.73)
gineering Magazine, No. 1, October, p. 49.

STOUGHTON (B.). — The manufacture of steel and rought iron in America. (4,500 words & fig.)

1907 **721** .1
gineering Magazine, No. 1, October, p. 81.

THOMSON (T. K.). — Machinery and methods for the cavation of sky-scraper foundations. (3,800 words fig.)

1907 **625** .13
ngineering Magazine, No. 1, October, p. 137.

HILDAGE (H. T.). — Underground workings in ew York City. (5,300 words & fig.)

Engineering News. (New York.)

1907 **721** .3 (01 & **62**. (01
ngineering News, No. 13, September 26, p. 342.

Strength tests of hooped concret columns. (2,000 words fig.)

1907 **621** .33 (.73)
ngineering News, No. 16, October 17, p. 397.

SMITH (W. N.). — Single-phase electric traction on e Rochester division of the Erie R. R. (7,000 words fig.)

1907 **62**. (01 & **624** .2 (01
gineering News, No. 17, October 24, p. 438.

HATT (W. K.). — A note on the effect of the time ement in loading reinforced concrete beams. (1,000 rds, 4 tables & fig.)

Indian Engineering. (Calcutta.)

1907 **621** .87
dian Engineering, No. 13, September 28, p. 204.

A new type of Breakdown crane for the Great Indian ninsula Railway. (550 words & fig.)

Locomotive Journal. (Leeds.)

1907 **625** .151
Locomotive Journal, No. 10, October, p. 467.

Railway permanent-way points and crossings—taking out quantities. (550 words & fig.)

Locomotive Magazine. (London.)

1907 **656** .222.1 (.42)
Locomotive Magazine, No. 182, October 15, p. 176.

Record run on the Great Western Ry. (900 words & fig.)

Proceedings, Institution of Mechanical Engineers. (London.)

1907 **621** .14
Proceed., Institut. of Mech. Eng., No. 2, March-May, p. 393.

BEAUMONT (W. W.). — Petrol motor-omnibuses. (30,000 words, 1 table & fig.)

1907 **621** .13 (06 & **625** .2 (06
Proceed., Institut. of Mech. Eng., No. 2, March-May, p. 495.

RICHES (T. H.). — Address by the president (3,300 words & fig.)

1907 **621** .131.3
Proceed., Institut. of Mech. Eng., No. 2, March-May, p. 525.

IVATT (H.A.). — Notes on road trials of three express passenger-engines, carried out on the Great Northern Railway in 1906. (400 words, 2 tables & fig.)

Railroad Gazette. (New York.)

1907 **385**. (07.4 (.43)
Railroad Gazette, No. 13, September 27, p. 362.

Railroad meseum of the German government. (1,400 words & fig.)

1907 **621** .132.5
Railroad Gazette, No. 14, October 4, p. 384.

Details of Mallet articulated compound locomotive. (1,800 words & fig.)

1907 **625** .154
Railroad Gazette, No. 14, October 4, p. 389.

Turntable deflection. (600 words & fig.)

1907 **621** .132.3
Railroad Gazette, No. 14, October 4, p. 390.

Four cylinder simple express locomotives; Great Western Railway. (400 words & fig.)

1907 385 .11 (.73)
Railroad Gazette, No. 15, October 11, p. 418.

MAHL (W.). — Equipment depreciation and renewal. (2,400 words.)

1907 621 .33 (.73)
Railroad Gazette, No. 15, October 11, p. 422.
— No. 16, — 18, p. 461.

SMITH (W. N.) — Electrification of the Rochester division of the Erie Railroad. (6,600 words & fig.)

1907 388 & 621 .33
Railroad Gazette, No. 15, October 11, p. 425.

MORRIS (R.). — Electric railway competition. (3,200 words & fig.)

1907 385 .1 (.73)
Railroad Gazette, No. 16, October 18, p. 452.

MATHER (R.). — The railroad problem. (5,000 words.)

1907 656 .25 (01
Railroad Gazette, No. 16, October 18, p. 456.

A method of uniform signaling. (1,000 words & fig.)

1907 625 .212
Railroad Gazette, No. 17, October 25, p. 495.

NORRIS (G. L.). — Causes of defects and failures of steel tires. (1,800 words & fig.)

Railway Age. (Chicago.)

1907 621 .132.3 (.42)
Railway Age, No. 1633, September 27, p. 420.

LAKE (C. S.). — British 4-cylinder locomotives. (1,800 words, 1 table & fig.)

1907 621 .13 (06.4 (.73)
Railway Age, No. 1634, October 4, p. 461.

Exhibits of the Baldwin locomotive works and the American locomotive company. (1,500 words & fig.)

1907 621 .33 (.73)
Railway Age, No. 1635, October 11, p. 494.

SMITH (W. N.). — Electrification of the Rochester division of the Erie Railroad. (5,200 words & fig.)

1907 385 .21 (.73)
Railway Age, No. 1635, October 11, p. 502.

HARAHAN (J. T.). — The complementary nature of water transportation as allied to transportation by rail. (1,700 words.)

1907 621 .33
Railway Age, No. 1636, October 18, p. 527.

DARLINGTON (F.). — The field for electricity on steam railways. (3,300 words & fig.)

1907 621 .134.3
Railway Age, No. 1636, October 18, p. 541.

The Toltz locomotive superheater. (800 words & fig.)

1907 621 .132.8
Railway Age, No. 1637, October 25, p. 570.

Motor car on the Great Western Railway of England. (700 words & fig.)

1907 625 .154
Railway Age, No. 1637, October 25, p. 575.

Modern turntables. (600 words & fig.)

Railway and Engineering Review. (Chicago.)

1907 621 .13 & 621 .335
Railway and Engineering Review, No. 39, September 28, p. 842.

Steam locomotive versus electric locomotive (6,000 words, 1 table & fig.)

1907 621 .134.3
Railway and Engineering Review, No. 40, October 5, p. 863.

Superheating with compound locomotives. (1,800 words, 1 table & fig.)

1907 621 .134.3
Railway and Engineering Review, No. 40, October 5, p. 868.

Toltz locomotive superheater. (550 words & fig.)

1907 621 .132.8
Railway and Engineering Review, No. 40, October 5, p. 873.

New motor coaches on Intercolonial Railway. (500 words & fig.)

1907 621 .33 (.436)
Railway and Engineering Review, No. 41, October 12, p. 880.

The Vienna-Baden Railway. (1,700 words & fig.)

1907 656 .25 (01
Railway and Engineering Review, No. 41, October 12, p. 884.

A method of uniform signaling. (1,100 words & fig.)

1907 625 .233
Railway and Engineering Review, No. 41, October 12, p. 888.

Electric train lighting. (650 words & fig.)

1907 621 .33
ilway and Engineering Review, No. 41, October 12, p. 893.

Single-phase or three-phase generation for single-ase railways. (1,200 words & fig.)

1907 725 .33
ilway and Engineering Review, No. 42, October 19, p. 903.

Standard steel water tanks, C. R. I. & P. Ry. (250 ords & fig.)

1907 624 .8
ailway and Engineering Review, No. 43, October 26, p. 922.

Page bascule railroad bridge over the Chicago River. 50 words & fig.)

1907 725 .33
ailway and Engineering Review, No. 43, October 26, p. 928.

Report on roundhouse smoke jacks. (2,500 words fig.)

Railway Engineer. (London.)

1907 621 .132.3
ailway Engineer, No. 333, October, p. 302.

De Glehn compound 4-6-0 locomotives; Paris-Orléans ailway. (1,300 words & fig.)

1907 656 .256
ailway Engineer, No. 333, October, p. 309.

Tyer and Co.'s "lock-and-block". (700 words & fig.)

1907 656 .257 (.73)
ailway Engineer, No. 333, October, p. 320.

Recent signalling in America. (500 words & fig.)

1907 625 .242
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12-ton hopper balast wagons; Caledonian Railway. 300 words & fig.)

Railway Gazette. (London.)

1907 385 .4 (.42)
ailway Gazette, No. 14, October 4, p. 323.

MARRIOTT (H.). — The organisation of an English ailway. (1,100 words & fig.)

1907 621 .335
ailway Gazette, No. 14, October 4, p. 327.

Electric locomotives of the Pennsylvania Railroad. 1,000 words & fig.)

1907 388 (.73)
Railway Gazette, No. 14, October 4, p. 328.

Rapid transit conditions in New York. (3,400 words & fig.)

1907 656 .212.6
Railway Gazette, No. 14, October 4, p. 333.

LAKE (C. S.). — Electric crane equipment at the L. & Y. R. wool and cotton warehouses at Bradford and Bolton. (1,400 words & fig.)

1907 625 .232
Railway Gazette, No. 14, October 4, p. 335.

First class dining car, Lancashire & Yorkshire Railway. (300 words, 1 table & fig.)

1907 385. (07.4 (.43)
Railway Gazette, No. 15, October 11, p. 354.

Railroad museum of the German government. (1,500 words & fig.)

1907 625 .234
Railway Gazette, No. 16, October 18, p. 371.

Laycock's low pressure steam heating system for railway carriages. (500 words & fig.)

1907 625 .154
Railway Gazette, No. 16, October 18, p. 373.

Turntable deflection. (700 words & fig.)

1907 621 .132.3
Railway Gazette, No. 16, October 18, p. 374.

Four cylinder simple express locomotives; Great Western Railway. (5,000 words & fig.)

1907 621 .132.8
Railway Gazette, No. 16, October 18, p. 382.

New rail motor Port Talbot Railway. (400 words & fig.)

1907 656 .281
Railway Gazette, No. 16, October 18, p. 384.

The Shrewsbury derailment. (700 words & fig.)

1907 621 .87
Railway Gazette, No. 17, October 25, p. 396.

A new self-propelling Breakdown crane for railway work. (550 words & fig.)

1907 621 .33 (.73)
Railway Gazette, No. 17, October 25, p. 398.

SMITH (W. N.). — Electrification of the Rochester division of te Erie Railroad. (2,800 words & fig.)

1907 621 .33
Railway Gazette, No. 17, October 25, p. 405.

A 2,000-volt continuous-current railway. (1,400 words & fig.)

Railway Machinery. (New York.)

1907 **621** .132.3
Railway Machinery, October, p. 65.

Pacific type locomotive for the Pennsylvania Railroad. (600 words & fig.)

1907 **621** .133.3
Railway Machinery, October, p. 69.

WELLS (M. E.). — Causes of leaks in locomotive boiler tubes. (3,300 words & fig.)

Railway Magazine. (London.)

1907 **656** .222.1 (.42)
Railway Magazine, No. 124, October, p. 296.

ROUS-MARTEN (C.). — British locomotive practice and performance. (3,600 words & fig.)

1907 **624** .8
Railway Magazine, No. 124, October, p. 317.

BYWELL (E. M.). — Swing and other opening bridges. (4,300 words & fig.)

1907 **621** .335
Railway Magazine, No. 124, October, p. 351.

The Metropolitan Railway's new electric locomotives. (1,300 words & fig.)

Railway Master Mechanic. (Chicago.)

1907 **725** .33
Railway Master Mechanic, No. 10, October, p. 341.

Locomotive and car repair shops, Frisco system. (2,500 words & fig.)

Railway Times. (London.)

1907 **625** .232
Railway Times, No. 14, October 5, p. 341.

New invalid and family saloons on the South Western Railway. (500 words & fig.)

1907 **656** .253
Railway Times, No. 14, October 5, p. 342.

Automatic track circuit signalling on the Great Western Railway. (700 words & fig.)

1907 **621** .132.8
Railway Times, No. 16, October 19, p. 389.

Steam railway motor coaches for the East Indian Railway. (700 words & fig.)

South African Railway Magazine. (Johannesburg.)

1907 **385** .3
South African Railway Magazine, No. 7, October, p. 529.

SKILLICORN (J. J. K.). — Government control of railways. (7,000 words & 1 table.)

Street Railway Journal. (New York.)

1907 **621** .33 (.73)
Street Railway Journal, No. 15, October 12, p. 650.

SMITH (W. N.). — Single-phase electric motive power on the Rochester division of the Erie Railroad. (9,000 words & fig.)

1907 **621** .33 (.73)
Street Railway Journal, October 12 (supplement), p. 540.

General features of the New York Central electrification. (1,000 words & fig.)

1907 **621** .331 (.73)
Street Railway Journal, October 12 (supplement), p. 544.

Power station practice of the New York Central. (4,200 words & fig.)

1907 **621** .332 (.73)
Street Railway Journal, October 12 (supplement), p. 552.

Power distribution system of the New York Central. (5,000 words & fig.)

1907 **621**. 331 (.73)
Street Railway Journal, October 12 (supplement), p. 560.

Sub-station practice of the New York Central. (2,800 words & fig.)

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Street Railway Journal, October 12 (supplement), p. 565.

Electric rolling stock of the New York Central. (7,000 words & fig.)

1907 **621** .33 (01 (.73)
Street Railway Journal, October 12 (supplement), p. 571.

Maintenance of electric rolling stock on the New York Central. (4,500 words & fig.)

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Effect on terminal operation of the New York Central electrification. (1,500 words.)

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Street Railway Journal, October 12 (supplement), p. 581.

Electrical operation on the West Shore Railroad. (5,000 words & fig.)

1907 **621** .331 (.73)
Street Railway Journal, October 12 (supplement), p. 587.

Operating features of the Long Island City power station of the Pennsylvania Tunnel and Terminal Railroad Company. (4,200 words & fig.)

1907 **621** .331 (.73)
Street Railway Journal, October 12 (supplement), p. 595.

Substation and power transmission practice of the Long Island Railroad. (3,300 words & fig.)

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Street Railway Journal, October 12 (supplement), p. 601.

Maintenance of electric rolling stock of the Long Island Railroad. (3,000 words & fig.)

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Street Railway Journal, October 12 (supplement), p. 604.

Operation of electric locomotives by the New Haven Railroad. (4,400 words & fig.)

1907 **621** .33 (01 (.73)
Street Railway Journal, October 12 (supplement), p. 608.

Electric railway practice of the New Haven Railroad. (3,800 words & fig.)

1907 **621** .331 (.73)
Street Railway Journal, October 12 (supplement), p. 615.

The power station practice of the West Jersey & Seashore Railroad. (2,400 words & fig.)

1907 **621** .332 (.73)
Street Railway Journal; October 12 (supplement), p. 618.

The distribution and sub-station system of the West Jersey & Seashore Railroad. (4,000 words & fig.)

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Operating features of the electrically equipped section of the Erie Railroad. (2,000 words & fig.)

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1907 **621** .33 (.4
Street Railway Journal, October 12 (supplement), p. 638.

DAWSON (P.). — Electrical equipment of main line railways in Europe. (7,200 words & fig.)

1907 **621** .338
Street Railway Journal, No. 17, October 26, p. 845.

The New York cars of the pay-as-you-enter type. (800 words & fig.)

Tramway & Railway World. (London)

1907 **625** .14 (01
Tramway & Railway World, No. 17, October, p. 277.

Track construction and corrugation. (3,600 words & fig.)

In Italian.

Ingegneria ferroviaria. (Roma.)

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Ingegneria ferroviaria, nº 19, 1º ottobre, p. 309.

Il prossimo congresso ferroviario internazionale. (900 parole.) (V. *Bulletin du Congrès des chemins de fer*, nº 5, mai 1907.)

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Revista de obras públicas. (Madrid.)

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evista de obras públicas, nº 1671, 13 de octubre, p. 547.

Ventilacion de los metropolitanos subterraneos. (1,400 labras.)

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Túnel del Simplon. (2,800 palabras & fig.)

In Dutch.

Locomotief. (Rotterdam.)

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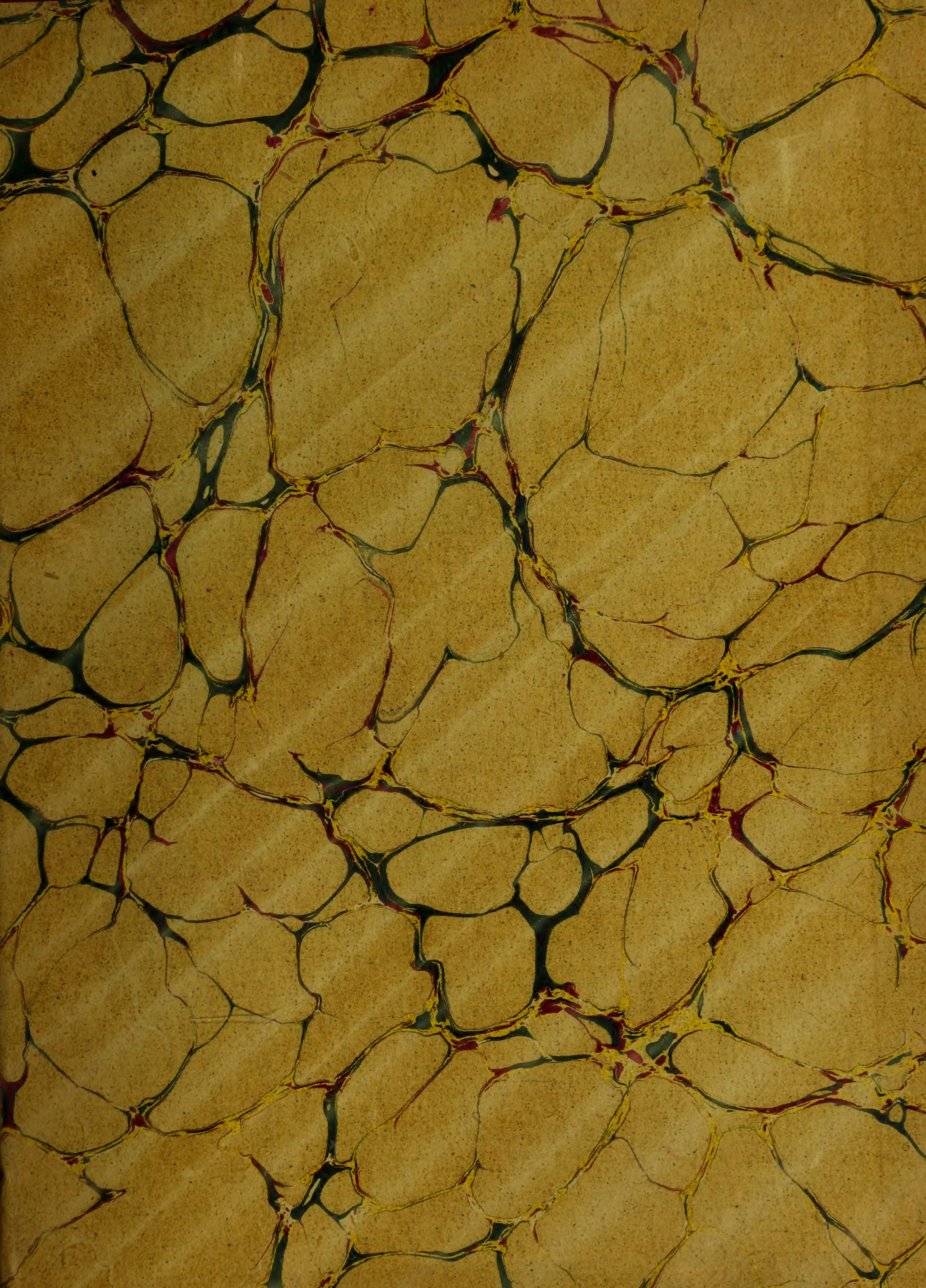

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